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RUBBER RESEARCH INSTITUTE OF MALAYA

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The Rubber Research Institute of Malaya

The Institute was established under the Rubber Research Institute of Malaya Enactment 1925, amended in 1934. It was founded for the purpose of research into rubber production in all its aspects and for the provision of information on the results of research. Funds are provided by a voluntary cess on the exports of rubber from Malaya. Contributions are also received from other producing territories—Nigeria, Sarawak, Brunei and North Borneo. The Institute is administered by a board consisting of Government nominees and selected representatives from planting organisations.

Three Divisions, Soils, Botanical and Pathological, are concerned with the cultivation of the rubber tree and the harvesting of the crop. The Chemical Division carries out investigations into the conversion of the crop into marketable forms. There is also a Statistics Division and a Publications and Information Section which includes the Library.

The Smallholders' Advisory Service has the task of conveying the results of research to the large rubber smallholding community of Malaya. The Estates Advisory Service provides routine advice to all estates, that is all planted areas over 100 acres. The Chemical Division has an Advisory Service which gives advice to estates on the processing of rubber and also a Technical Service to manufacturers in South-East Asia.

The main research buildings are at Kuala Lumpur. The Experiment Station, about 3,000 acres in extent, is at Sungei Buloh, 16 miles from Kuala Lumpur.

Report of the Board

On 31 December 1961, the members of the Board under its Constitution were:

The Director of the Institute (Dr C. C. Webster), Chairman

The Controller, Export Commodities Division, Ministry of Commerce and Industry (Mr. Lew Sip Hon)

The Acting Director of Agriculture (Mr J. S. Ure)

Members appointed under section 5(i)(b) of the Enactment (F.M.S. Cap. 108) to represent Smallholders:

The Hon'ble Enche Abdul Jalil bin Haji Aminudin, P.J.K., J.P.
Mr Yap Kim Hock, J.P.

Members appointed under section 5(i)(b) of the Enactment (F.M.S. Cap. 108) to represent the Rubber Producers' Council, Rubber Growers' Association and the Malayan Estate Owners' Association :

Mr Soon Cheng Sun, J.M.N., J.P.
Mr J. Brown
The Hon'ble Mr Choo Kok Leong
Mr S. Sandison
Mr Chan Hin Cheung

Dr C. C. Webster was appointed Director of the Institute by His Majesty the Yang di-Pertuan Agong with effect from 16 January 1961. Mr C. G. Akhurst retired from the post of Deputy Director on 10 October 1961 and Mr C. W. Brookson was appointed Acting Deputy Director as from that date. Dr J. W. Blencowe has been appointed Deputy Director and expects to take up his duties on 1 June 1962.

Mr A. W. Goode retired from the Board on leaving Malaya and Mr Chan Hin Cheung was appointed in his place with effect from 1 April, 1961.

Mr Lim Kim Cheng retired and the Ministry of Finance appointed Mr Lew Sip Hon as Financial Member in his stead with effect from 1 July 1961.

Mr J. Brown was on leave from 12 July to 18 October 1961, and Mr L. H. N. Davis acted as substitute.

The Permanent Committee. The members of the Permanent Committee consisting of five Board members were:

The Director, Dr C. C. Webster, Chairman
The Financial Member, Mr Lew Sip Hon (*vice* Mr Lim Kim Cheng)
The Hon'ble Enche Abdul Jalil bin Haji Aminudin, P.J.K., J.P.
Mr J. Brown
Mr Soon Cheng Sun, J.M.N., J.P.

The Ministry of Commerce and Industry appointed Mr Lew Sip Hon to be a member of the Permanent Committee with effect from 1 July 1961 in place of Mr Lim Kim Cheng.

Mr L. H. N. Davis acted on the Permanent Committee for Mr J. Brown while the latter was away from Malaya on leave from 12 July to 18 October 1961.

Committee Meetings. During 1961 the Board held three statutory meetings and one special meeting. The meeting on 14 March 1961 was attended by Sir Frank Engledow, a member of the Co-ordinating Advisory Committee.

The Permanent Committee held four statutory meetings, and in addition one sitting as an Estimates Committee and seven sittings as a Selection Committee.

The Director, Dr C. C. Webster, visited London in May and October to attend meetings of the Co-ordinating Advisory Committee.

The Joint Committee of the Board and the R.R.I.M. Staff Union met twice.

Policy. A Bill entitled 'The Rubber Research Institute of Malaya Act 1961' was introduced into Parliament.

A Planters' Conference was held on 28 and 29 July 1961 and was attended by some 120 planters and representatives of the Planting Industry.

The Organisation and Methods Adviser of the Federal Treasury conducted a survey on all aspects of the administration of the Institute.

Owing to the success of the Smallholders' School at Ayer Pa'abas the Board agreed that a second school should be constructed near Kuala Kangsar. This is now complete and the first course is due to start on 12 March 1962.

Land is being sought for a sub-station on which a new planting or replanting programme can be carried out.

The Malayan Rubber Fund Board approved a programme for the Malayanisation of the R.R.I.M.

The Board acceded to a request by the Chairman of the Boards of the Administrators of the Government Rubber Replanting Schemes that the Smallholders' Advisory Officer should assist in the distribution of budwood to smallholders.

Finance. The Board's approved estimates of expenditure and revenue are given below (the audited accounts appear at the end of this report).

	Approved Estimates	*Actual Expenditure*
Headquarters and Laboratories	$7,807,920	$6,342,420
Experiment Station, Sungei Buloh	1,269,843	1,035,913

Staff. During 1961 six Division A and eight Division B officers took up appointments and two Division A officers resigned. At the end of the year there were vacancies on the establishment for seven Division A and five Division B officers.

C. C. WEBSTER
Director and Chairman of the Board

Report of the Director

RESEARCH

The basic aims of our research have always been, first, increased efficiency and lowered costs of production and, second, improvement in the uniformity and quality of the product. These two broad objectives are those common to research on most crops and progress towards them is normally slow with a perennial tree crop. Nevertheless, with the increasing competition from synthetic rubber it is essential that every effort be made to achieve progress as rapidly as possible.

The prospects for making progress towards the first objective—more efficient and cheaper production—are pre-eminently in the field of biological research, particularly by means of increased yields per tree and per acre, reduction in the period of immaturity of the trees, cheaper maintenance of plantations and more efficient exploitation of the tree. It is, however, self-evident that the majority of investigations on rubber trees must necessarily take many years and hence progress can only be made by fully maintaining long term projects, while at the same time seizing any opportunities which may exist for making more speedy, even if limited, forward thrusts towards our objectives.

As indicated in later paragraphs, certain short- and medium-term projects appear to warrant priority because they have a good chance of enabling advances to be made within a few years. Thus, there appear to be good prospects that investigations into methods of propagation and the use of cover plants and fertilisers may enable a substantial reduction to be made in the time of immaturity. More intensive work on weed control coupled with cover plant experiments gives promise of cheapening the maintenance of young rubber. Leaf analysis seems likely to develop into a useful aid in the diagnosis of fertiliser requirements. Current work on tapping and yield stimulation, including method studies of tapping and collection, has prospects of providing means of obtaining higher yields per tapper. Economies have already been made in root disease control measures and experiments in hand will probably show that a further reduction in costs can be made. High priority work on the important problem of 'brown bast' is still at too early a stage to allow us to say when it will produce results of practical application.

At the same time there are long-term projects of the highest importance which must be fully maintained and which may be expected to yield more considerable, although perhaps more gradual, improvements. The most effective single means of reducing costs of production is that of increasing yields per acre by replanting with improved planting materials; hence the importance of continuing the programme of breeding and of seeking methods of early selection and yield production to speed it up. Basic research into the physiology of latex production and flow and on the role of natural auxins in *Hevea* seems essential in order to expand existing knowledge and thus form a basis for more direct and practical studies.

The work of the Chemical Division is less likely to result in any marked reduction in cost of production in the near future but aims much more at the achievement of the second objective—improvement in the uniformity and quality of the product, including also the development of new rubbers having properties superior to those of existing types. Such improvements are already of great importance now that natural rubber is competing with the more standardised synthetics that

are sold to specification and well presented, and the development of new forms of natural rubber may prove to be of vital importance if the very considerable research effort now deployed in the synthetic industry should achieve the production of elastomers superior to any now marketed.

On the more fundamental side, the approach to these problems includes studies of the rubber hydrocarbon and of the non-rubber substances naturally occurring in latex. Earlier work which first suggested the possibility that the natural rubber hydrocarbon may not be a simple polyisoprene is being actively pursued. There appear to be good prospects that these studies will lead to the production of improved rubbers on a commercial scale. In the field of non-rubber substances, work is directed towards establishing which of these are of major importance in influencing the technological characteristics of natural rubber, since there appears to be a good chance of modifying the preparation of dry rubber to give a product with different and valuable properties.

On the technical side it appears likely that certain estate factory processes could be carried out more efficiently and studies to this end are being extended. At present they include preservation of field latex during collection and transport, treatment of scrap rubber, drying of sheet and crepe, ammonia recovery from latex skim, and effluent disposal.

RESEARCH OF THE BIOLOGICAL DIVISIONS

Breeding and Selection

More than 30,000 hand pollinations were made in 1961. The majority of these were for the main breeding programme which, as in previous years, involved the production of one large family by crossing two selected clones and of several small families made to test the combining ability of promising parents. A number of selfed progenies were produced; partly to determine the extent of self incompatibility and to test the progenies with a view to finding parents for superior seed gardens; partly in continuation of the small inbreeding programme. In addition, several experiments were undertaken to study factors involved in the fall of immature fruit and the low percentage success obtained in hand pollination.

Seedlings from the 1959 hand pollinations were grown at relatively wide spacing in the nursery for two years and observations made on their vigour, bud, leaf and branching characteristics. Clones were made only from the most vigorous seedlings in each family and were planted in a small scale clone trial. A replicated trial of random selections of the seedlings of fourteen families was planted in order to evaluate the families and to test the value of selection on vigour in the nursery.

Two further steps were taken in an effort to find means for forecasting yield and making early selections. First, bark samples were taken from the seedlings which were cloned and observations made on the number of rows and proportional area of latex vessels in the hope that these may later be correlated with the yield of both the seedlings and the clones. Second, clones from some of the 1959 seedlings, together with a number of well-known clones, were planted in a miniature trial at a spacing of 8×14 ft. Observations will be made on vigour, vegetative characters, rubber content of bark and petiole, and various types of test tapping will be done in order to examine the possibility of selecting clones for large scale trial after only eighteen months' or two years' observation in the miniature trial.

A total of 240 clones are being tested in post-war large scale trials of varying age on estates and at the Experiment Station. In the RRIM 600 series trials, 600 and 628 maintained their high yields, giving about 2400 lb per acre in the sixth year of tapping; very high yields were obtained after stimulation of clones 600, 605 and 607. Five new large scale clone trials were established during the year; these include the RRIM 700 series clones selected in 1960.

Propagation and Planting Methods

Various possible means of reducing the period of immaturity after planting rubber in the field are being investigated, including the use of cuttings and of budded stumps or entire budded plants in polythene bags. Small scale trials have shown that, with some clones, cuttings grow appreciably more vigorously than budded stumps while with others they do not. Cuttings do not produce tap roots but quickly develop extensive laterals; it is not yet known whether such a root system will prove mechanically stable. Larger scale experiments are planned to give a thorough comparison of buddings and cuttings of various clones.

A high degree of success has been achieved with the green budding technique when used for budding young seedlings in polythene bags or in the nursery.

Wind damage is an important problem, in particular with clone RRIM 501, and three lines of work are in progress. First, experiments are being made with various methods of pollarding and pruning to try to prevent or reduce wind damage in young mature stands of RRIM 501. Pollarding at any height greatly reduces the subsequent rate of girth increase and the yield. Partial pruning at twenty-seven feet had little effect on girthing but still reduced yield over the first year. The economics of these methods and their efficacy in preventing damage is not yet known. Second, the possibility of preventing wind damage in susceptible clones by postponing opening or by reducing tapping intensity is being studied. Third, background information on the nature of wind damage is being sought but no clear picture has yet developed. A preliminary survey of the incidence of damage in RRIM 501 showed no correlation with soil type or exposure but suggested that susceptibility is influenced by husbandry practices. In an experiment which has run for three years nitrogen fertiliser increased losses from wind damage but phosphate, potash and magnesium did not.

Soils and Manuring

Recent fertiliser experiments with immature rubber have confirmed previous findings that on coastal soils only nitrogen fertiliser benefits growth, while on inland soils the main response has been to nitrogen and phosphate, with variable response to potassium and magnesium. In current experiments with young mature rubbers, growth responses within four years of the first fertiliser application have been recorded but no yield response so far. With older rubber there has been no increase in yield due to fertilisers in nine trials started within the last four years; in seven other trials the pattern of yield response was not consistent although significant increases due to nitrogen were obtained.

Further information is needed in order to be able to make more precise recommendations for the manuring of rubber according to soil type and fertility which are now required if the maximum return is to be obtained from expenditure on fertilisers. Discrimination is necessary between some of the soil types within the

three main classes—coastal alluvia, inland clays and clay loams, and inland alluvial sands—for which general recommendations are now made. New nutritional problems are created by new planting on soil types hitherto little used for rubber and extensive replanting on soils which have suffered some depletion of fertility. Consequently, work has started on the more detailed study of some soil types by examination in the field, analyses, pot experiments and *Hevea* leaf analyses. This, it is hoped, will give an indication of the relationships between soil nutrient status and the nutrient status and performance of the tree, and of those nutrient elements which may be limiting optimum performance. On the basis of these results, suitable fertiliser experiments will be started.

Leaf analysis is being developed as an aid to the diagnosis of fertiliser requirements. A satisfactory technique for leaf sampling has been worked out and the effect of storage of samples before drying on leaf dry weight and nutrient concentrations has been determined. Investigations into the relationship between leaf nutrient status and tree performance, ultimately aiming at the establishment of optimum levels for leaf nutrients, are making progress and it is now possible to recognise, under certain conditions, levels below which fertiliser response is likely and above which it is unlikely.

Cover Plants

Experiments are showing consistently that leguminous mixtures have the best effect on the growth of the young rubber trees and can markedly reduce the period of immaturity, but that the effect of covers of the less vigorous grass species is not much inferior. Natural regeneration of indigenous bushes, ferns and creepers causes poorer growth of the trees and the depressive effect of *Mikania scandens* is now well established, although not fully understood. Legumes increase the nitrate nitrogen content and probably also the total nitrogen and organic matter contents of the soil, resulting in a higher nitrogen level in the leaves of the trees: their use is likely to permit economies in fertiliser usage. There is a much greater weight of *Hevea* feeding roots in the cover plant litter and in the top 3 in. of soil in the legume plots than in those under grass, naturally regenerated cover or *Mikania.*

Amongst recently introduced legumes, *Calapogonium caeruleum* holds considerable promise if seed production can be improved. *Stylosanthes guyanensis* (subspecies *gracilis)* has the great advantage of rapidly establishing a dense, almost weed-free cover, but evidence of its effect on the growth of rubber is at present contradictory.

Weed Control

Weed control forms a major item in the recurrent cost of immature rubber and as there is a possibility of the cheap herbicide, sodium arsenite, being banned, work in this field is particularly important and has been intensified with the appointment of an agronomist who has specialised in this work.

No cheap alternative to sodium arsenite has yet been found. The non-toxic, pre-emergence weed-killer Simazine is effective in maintaining weed-free conditions on initially clean weeded land and may be effective for two or three months longer than control by hand weeding alone. Amitrole has some pre-emergence effect and its application, together with Simazine, considerably increases the latter's

effect where the main weed is *Paspalum conjugatum*. These herbicides can be valuable in controlling weed seeds germinating between the rows of young legume covers, but require care in application as damage may ensue if the spray reaches the cover. A pre-emergence herbicide that will not damage legumes is being sought.

Paraquat, a non-toxic, contact herbicide, has been found effective against most common weeds except some *Cyperus* species; it can be sprayed right up to rubber trees which have developed brown bark although it kills rubber if sprayed on leaves or green stems. At present it is somewhat expensive.

For mixed stands of the grasses *Axonopus compressus* and *Paspalum conjugatum* a mixture of dalapon and amitrole (aminotriazole) has been recommended, since the former is effective against *Axonopus* but not against *Paspalum* while the reverse is the case for amitrole. It has now been shown that there is a synergistic effect between the two chemicals when sprayed on *Axonopus* and an antagonistic effect when applied to *Paspalum:* if *Axonopus* is the main weed but others are present it is best to use the mixture of amitrole and dalapon; if *Paspalum* is the main weed it is best to spray it out first with amitrole.

There is scope for improvement in methods of applying herbicides in rubber plantations and this is receiving attention. Application has normally been at the rate of 100 gallons per acre but experiments have shown that with dalapon, Paraquat and dalapon-amitrole mixtures, 40 gallons per acre is just as effective when the standard knapsack sprayer equipment is used. Further reduction in gallonage and increase in efficiency may be possible if other nozzles are used to reduce droplet size, but very small droplet size will increase risk of spray damage through drift. Work is also in progress on the use of wetting agents.

Tapping and Yield Stimulation

The cost of tapping and collection forms a large proportion of the total cost of production and, despite advances made in recent years, there appear to be promising possibilities of further reducing these costs.

With young rubber it is obviously desirable to exploit the tree to the highest possible intensity compatible with continued satisfactory growth and sustained yields. Some high yielding clones girth very slowly after tapping begins, and amongst these RRIM 501 is prone to trunk snap. Trials have been started to see if postponing opening will give stronger trunks and whether the initial loss in yield can be offset by higher yields from better developed trees. Another possibility is to obtain better girthing by reduced tapping intensity. Preliminary results suggest that girthing is enhanced by employing an alternate-daily periodic tapping system of 67% intensity and, although this will result in an initial reduction in yield, it is possible that the loss can be offset by more intensive tapping coupled with yield stimulation once the period of rapid growth of the tree has passed.

It is desirable to start yield stimulation at the earliest stage commensurate with sustained economic returns from the tree. The use of stimulants on the second panel of virgin bark has, initially, given very high yields for some clones but it remains to be seen how long these will be maintained. The combined effect of tapping systems of different intensities and different levels of fertiliser application, with and without yield stimulation, is also being studied. A significant effect of manuring on girthing has been established but not yet on yield; there have been no significant interactions.

With older trees an experiment just completed has shown that, in view of the very good response to stimulation of single-cut systems, double-cut (high and low) tapping should not be introduced until the bark of first renewal has been fully exploited. The response of such double-cut systems of 133% and 200% intensity to stimulation is not maintained after a period of high yields lasting from 1½ to 2 years. A double-cut third daily periodic system of 100% intensity, which should reduce tapping costs and bark consumption, is now being tried, with and without stimulants, in five new experiments.

Trials have shown that tapping and stimulation of high panels of a number of the RRIM 500 series clones has given very satisfactory results, with particularly high yields from RRIM 501 and 519.

A study has been made of the influence of size of tapping tasks on yield per acre, per tapper and on standard of tapping, using Tjir 1 clonal seedlings. It appears likely from the results of this experiment that the combination of increased task size and judicious application of yield stimulants will permit increased output per tapper, especially when low panels are being exploited.

Work has continued on the practical application of yield stimulants. Monthly application to renewing bark above the cut has certain advantages over less frequent application below the cut in that it results in a more steady yield response, less fluctuation in dry rubber content and obviates the need for scraping the bark. However, it results in some damage to the renewing bark and as recent experiments have failed to find means of preventing this damage, the method cannot be recommended when the treated bark is to be tapped again. Experiments have now indicated that when stimulants are applied to virgin bark below the cut only a very light scraping is needed, instead of the customary deeper scraping. If these findings are confirmed in new trials now in progress on both virgin and renewed bark, an appreciable saving in the cost of applying stimulants below the cut should be possible.

It has been found that application low down on the trunk on the same side as the cut gives higher yield increases than application immediately below the cut; such application of the present commercial stimulants near ground level would, however, be likely to cause bark damage. Preliminary experiments have therefore been started to see if damage can be avoided and good yield increases obtained by applying low concentrations to a larger area of bark.

Physiology of Latex Production and Flow

A number of short-term experiments were carried out in efforts to obtain information on the factors controlling latex flow and the mode of action of yield stimulants. Measurements showed some fall in the viscosity of latex when trees were treated with yield stimulants, suggesting a possible means whereby the latter produce a more rapid flow, but further confirmatory observations are required. No evidence was obtained of an increase in osmotic concentration, (hence increased turgidity of vessels, leading to higher rate of flow), resulting from stimulation. Observations unexpectedly indicated reduced stability of the latex following stimulation, but this again requires confirmation. Dendrometer measurements were made on the trunks of stimulated and control trees to see if there was any difference between them in the contraction of diameter following tapping, which might indicate an effect of stimulants on the water status of the bark, or on the

elasticity and plasticity of the cell walls. No differences were found but, again, further work is required.

A start was made on a study of the occurrence and nature of natural growth substances in *Hevea* with the primary object of obtaining information which may aid in the elucidation of the processes of latex production and flow.

Pests and Diseases

Attention has continued to be concentrated on the control of the three main root diseases, *Fomes lignosus*, *F. noxius* and *Ganoderma pseudoferreum*. In replanting, one approach is pre-planting treatment of the old stand by rapid killing of the old trees or stumps, permitting the access of saprophytic fungi and reducing the hazard of disease spread. In an earlier experiment poisoning the standing trees was found to be superior to felling and then poisoning the stumps. Tree poisoning, however, has a disadvantage in the damage done when the trees break up. The effect of felling trees at intervals after poisoning has therefore been studied and, although the effects on rate of death of roots and the significance of starch reserves in them have not been fully elucidated, it appears that for the control of root disease it is satisfactory to poison the old trees and fell them two months later.

An experiment comparing various degrees of eradication of diseased trees in the old stand has strongly indicated that it is not economic to attempt eradication of *F. lignosus* before replanting, provided that a high standard of upkeep is maintained in replanting and that the essentials of root disease control are scrupulously carried out on the young trees.

The full 'classical' treatment for infected trees in a young stand comprises excision of wood penetrated by the fungus, removal of surface rhizomorphs, surface application of a tar acid fungicide and tarring all wounds made in exposing roots or in excising infected tissue. In investigations, designed to find the essential minimum treatment needed to save a tree infected with *F. lignosus*, it has been shown that the essential operation is to cut the tree off from the source of infection; epiphytic mycelial and rhizomorph growth is harmless and requires neither removal nor fungicidal treatment provided it has no food base to support it.

When trees are opened at the collar for inspection and, if necessary, for treatment, (as is regularly done as a control measure in areas where disease is present) it would be a great advantage if a lasting protection could be given to the collar by application of a fungicide which would remain active and stable in the soil. In investigations with this aim in view certain materials are showing great promise.

A research officer is posted to Trinidad to study the life history, cytology and variability of the fungus *Dothidella ulei* and the host-parasite relationships. A collection of *Hevea* material being established in Trinidad should provide a range of differential hosts for the purpose of typifying physiological races of the fungus and permit the screening of material to provide resistant selections for further breeding work.

Dry Trees

The partial or total drying up of a proportion of trees, which may develop the symptoms known as brown bast, and the consequent reduction in yield and increase in tapping costs, is an important problem which has long been with the

industry. The many previous investigations, in Malaya and elsewhere, have led to no definite conclusions as to the cause, or causes, of this condition nor to satisfactory control measures. The problem is now being attacked by a team of research officers who are investigating the possibilities of the condition being due to infection, to mineral nutrition, to anatomical changes or to exhaustion of carbohydrates from tapping. Field experiments are in progress to determine the effect of various tapping intensities, reduced length of cut, resting from tapping and excision of affected bark as possible control measures.

Statistics

The Statistics Division is primarily concerned with the design of experiments and the analysis and interpretation of data resulting therefrom, but in 1961 it has also assisted the Smallholders' Advisory Service in the planning of three sample surveys and the processing of the survey data. Towards the end of the year the Head of the Division started some preliminary studies of costs of production and work study investigations, the latter being mainly method studies of the operations of tapping, collection of latex and scrap and their transport to the factory.

RESEARCH OF THE CHEMICAL DIVISION

Fundamental Research

Studies in latex proteins, which were undertaken as part of a programme to obtain more information on the nature and function of the non-rubber constituents of latex, have demonstrated the presence of thirty different protein components. Eight have been found by paper electrophoresis in the bottom fraction, separated from fresh latex by high speed centrifugation, and twenty-two by starch gel electrophoresis in serum separated in the same way.

In connection with optical microscope studies of latex the presence of 'lutoid' particles similar to those occurring in latex from *Hevea brasiliensis* has been demonstrated in twenty different lactiferous plants covering eight different families.

The electron microscope received in May will be used for further studies of the ultra-structure of latex and latex vessels. Initially, however, it has been employed to study the particle size distribution in latex, the objective being to examine the possibility of agglomerating the small particles in latex to larger ones, thus improving its technological behaviour.

Fresh raw rubber has been shown to contain active aldehyde groups, which may be attached to the rubber hydrocarbon chain; these reactive groups give rise to gel formation in dry rubber. By blocking their reactivity the hardening of rubber which normally proceeds during shipment can be inhibited and it is thus now possible to produce rubbers with constant Mooney viscosity. An interesting feature of this work is the observation that rubber from a newly opened tree contains a high proportion of gel and few aldehyde groups. As tapping proceeds, the gel content falls and a concomitant increase occurs in the number of active aldehyde groups present.

It has been found possible to control, within limits, the length of the added polymer side chains in preparing methyl methacrylate rubber grafts, by stepwise addition of the monomer. Graft rubbers with shorter side chains show improved technical properties.

Applied Research and Technology

About 30 substances have been evaluated as secondary and tertiary preservatives for latex concentrate and a number of systems have been found which appear to be satisfactory from a bactericidal point of view. The more promising of these have been selected for technological evaluation for the preparation of foam rubber and other latex products, with the hope of establishing a concentrate with characteristics definitely superior to current commercial types.

The relation between specific gravity and temperature has been established for 60 per cent ammonia-preserved latex over a range of temperatures from 4°C to 40°C. These data should be of value in establishing an agreed means for determining weight/volume relationships in the marketing of latex concentrate.

Examination of latex samples collected from two commercial estates where fertiliser trials were being carried out by Soils Division, showed a small increase in nitrogen content and a larger increase in phosphate content of the latex, about one year after starting treatment of the soil with ammonium sulphate and rock phosphate respectively. No effect of fertiliser treatment on latex concentrate properties was observed save in the case of ammonium sulphate manuring on one estate where a small but significant reduction in mechanical stability time (ASTM) was established.

Process Evaluation and Factory Studies

An experiment comparing the properties of different experimental types of general purpose rubber is in progress at the Experiment Station. The new rubbers include the flocculated rubber described by Liponski of the I.R.C.V. A special feature of the experiment is to study the uniformity of the new rubbers, as compared with RSS, over a period of at least one year.

Following an analysis of the contribution to total cost made by the individual processes concerned in normal sheet manufacture, a programme of work aiming at reducing the cost of sheet production is in hand. This follows two main lines. The first is concerned with coagulation and machining methods which, used in conjunction with revised drying techniques, would allow higher d.r.c. coagulation or would give thinner sheets from coagulation at normal d.r.c. levels. The second is aimed at an improved drying shed design to give more economic drying of normal sheet and to permit the drying of sheet produced by abnormal methods of coagulation and machining.

An experimental sheet rubber drying tunnel based on modified principles of water removal, derived from laboratory work, has been constructed at the Experiment Station and is now being commissioned.

An R.R.I.M. Double B type smokehouse incorporating novel features has been in operation at Sungei Buloh for about a year and a half. A notable development is an improved type of furnace, which is behaving well and promises to give double the life of the earlier type.

Small scale experiments to recover ammonia from latex skim produced in the centrifugation of latex to concentrate, promise economic recovery under suitable conditions. Trials with larger scale plant are planned for 1962.

The disposal of effluent from latex concentrate and sheet rubber factories has presented problems to a number of producers. Trials using biological treatment on a trickling filter have shown that this method holds considerable promise, since

it appears that much higher levels of pollution can be dealt with satisfactorily under Malayan conditions than is normally experienced in temperate climates. The possibility of utilising factory effluents, instead of disposing of them wastefully, is also being examined.

ADVISORY WORK

Smallholders' Advisory Service

This Division provides technical information and advice to smallholders by a variety of methods. In 1961, 74,281 advisory visits were made to individual smallholdings: instructors arranged 873 regular meetings of smallholders to discuss problems of topical interest, delivered 777 lectures to other groups and gave further lectures and demonstrations at 106 rural training courses organised by the Department of Agriculture. The four mobile units provided 303 demonstrations of sheet making and 342 film shows in different kampongs. The Service participated in 18 Agricultural Shows. At kampong centres and at the Ayer Pa'abas School a total of 109 training courses, attended by 2,097 students, were completed and a further 43 courses, attended by 1,174 students, were in progress at the end of the year. In addition 55 special courses were given to 1,589 settlers on F.L.D.A. schemes in several States and on fringe alienation schemes in Negri Sembilan.

Advisory articles suitable for smallholders were published in the Malay and Chinese versions of *Planters' Bulletin* and in the R.I.(R)B. newspaper. Leaflets describing the work of the Service and leaflets and posters urging the use of improved planting materials were issued. In the latter connection it may be noted that the trend towards the establishment of budgrafted rubber in preference to clonal seedlings continued on all new plantings.

In endeavouring to improve the quality of rubber and the return obtained by smallholders, the main effort was directed to the establishment, as the first step, of group processing centres provided with simple equipment where smallholders process their own latex. During 1961, 56 new centres were established as a direct result of advisory work bringing the total to 117 centres with 2,286 users producing good quality sheet at the rate of 2,198 tons per year. At 21 of the centres bulk sales of sheet are now made; at 5 of these bulk processing is also done.

Investigational work included a field survey of all 1954 replantings in Negri Sembilan under the replanting scheme, another of all replantings in Kelantan and Trengganu to which payment of instalments of the replanting grant had been deferred; also a sample survey of recently matured plantings to assess the importance of brown bast.

Estates Advisory Service

This Division, which was formed three years ago for the purpose of taking over routine advisory work from the biological research divisions, is primarily concerned with providing a service to the smaller estates although, on request, it also gives advice and makes visits to the larger, company-owned estates. Its activities again expanded during 1961 when a large number of enquiries were dealt with by correspondence, 559 visits were made to estates, 213 planters sought advice verbally at the Institute, and 43 parties of planters were conducted round the Institute and the Experiment Station. In connection with visits to the smaller estates a

number of informal gatherings of planters were arranged at which problems were discussed with the advisory officers. For the first time since 1938 a Planters' Conference was held at the Institute in July. It was attended by 114 planters and visiting agents. The first of the two days was devoted to papers and discussions and the second to a tour of the Experiment Station.

Chemical Advisory and Technical Services

Advice to estates on processing rubber has continued to be provided by the advisory section of the Chemical Division. The increase of rubber production in Malaya has resulted in a considerable proportion of the work of this section being devoted to the design of new factories and the expansion of existing ones. Discussions with R.I.D.A. and F.L.D.A. representatives on the collection of latex and factory layouts have also been held, in connection with the development of centralised factories for smallholdings.

The Institute continued to operate a technical service to rubber manufacturers in South-East Asia, the number of enquiries dealt with amounting to 199 as compared with 79 during 1960. The majority of these enquiries came from the Federation and Singapore, many entailing laboratory investigations. About 40% of the enquiries were from India; only a few of these required laboratory work.

Exhibitions and Shows

At the Malayan Agri-Horticultural Exhibition which was held in Kuala Lumpur in August, the Botanical Division showed a working mist propagation unit to demonstrate the technique and objects of making *Hevea* cuttings.

The Smallholders' Advisory Service made contributions of educational value at eighteen agricultural shows of various types in Malaya. Sheet making competitions were organised in conjunction with the exhibits. The Service also took part in the F.A.O. International Seed Campaign.

Publications and Library

In March 1961 regular publication began of *Planters' Bulletin* in the Malay and Chinese languages, thus making suitable advisory articles available to smallholders and small estate owners. By the end of the year distribution was as follows: Malay (Rumi) 3,800; Malay (Jawi) 6,700; Chinese 9,100. Distribution of the English version of *Planters' Bulletin* has increased from 3,500 to 4,500 over the two years 1960 and 1961, mainly in Malaya.

Alterations to and re-equipment of the Library have been completed and the stock rehoused on the new shelves which should provide sufficient space to allow for expected expansion during the next 10 years. Reclassification and cataloguing were still in progress at the end of the year.

STAFF AND STAFF TRAINING

Senior Staff Changes

Dr C. C. Webster, previously Professor of Agriculture at the Imperial College of Tropical Agriculture, University College of the West Indies, Trinidad, took up his appointment as Director of the Institute on 16 January.

Mr C. G. Akhurst retired from the post of Deputy Director on 10 October, having served with the Institute since 1930; Mr C. W. Brookson, Head of Botanical Division, acted as Deputy Director for the remainder of the year.

Dr J. W. Blencowe, Acting Director of the West African Cocoa Research Institute, New Tafo, Ghana, has been appointed Deputy Director; he is expected to assume duty in June 1962.

Mr R. S. Gale, Senior Chemical Engineer in Chemical Division, resigned in August after serving with the Institute for over ten years.

Mr G. F. J. Moir, Biochemist, resigned in May after six years service, to take up an appointment as lecturer in Biochemistry at the University of Malaya.

In total, six Division A and eight Division B officers took up appointments during the year; their names appear in the Senior Staff list at the end of this report.

Training of R.R.I.M. Staff

The Board of the R.R.I.M. continued its policy of assisting members of staff to obtain further training overseas as well as offering scholarships at the University of Malaya and at the College of Agriculture, Serdang. A more comprehensive scheme to provide for the training of Malayans to fill vacancies for research and advisory officers was approved by the Malayan Rubber Fund Board towards the end of the year and will begin operation in 1962.

Six scholarships were awarded to the College of Agriculture, Serdang, bringing the total of R.R.I.M. scholars at the College to twenty-one.

The Smallholders' Advisory Service organised three-month training courses at the R.R.I.M. Experiment station for prospective Rubber Instructors and Assistant Rubber Instructors: following the courses, five were appointed in the former grade and fifty-six in the latter grade. Thirty-seven serving Assistant Rubber Instructors attended short refresher courses.

Training of Non-R.R.I.M. Staff

Training was provided for a number of people who are not members of the Institute's staff. The Smallholders' Advisory Service accepted sixteen employees of other organisations for the three-month course for prospective R.R.I.M. staff mentioned above and ten F.L.D.A. assistants for courses at the Ayer Pa'abas school. The Estates Advisory Service provided short courses for estate assistants, for conductors and for officials of certain government bodies. Research and advisory officers gave all the lectures on rubber at the College of Agriculture, Serdang, and a ten-day practical course was arranged for the students at the Experiment Station. Several research officers gave lectures and practical classes in the course for the Licentiateship of the Institution of the Rubber Industry which has been sponsored by the Malayan branch of the Institution.

C. C. Webster
Director

Soils Division

The main work of Soils Division is to study the nutritional requirements of the rubber tree with the object of determining methods of fertiliser and cover plant usage which will give optimum growth and yield. Direct answers to our main problems are sought in field experiments with fertilisers and cover plants, where the response of trees to treatments is measured in terms of growth and yield. Leaf and soil analysis is carried out in these experiments to determine whether any relationship exists between the nutrient status of the soil and the nutrient status and performance of the tree. In this way it is hoped to develop methods of assessing the nutrient requirements of the tree so that fertilisers can be used with maximum efficiency.

To extend our knowledge concerning the major soil types under rubber cultivation, soil and leaf analysis is also carried out on non-experimental areas and more information on the nutrient status of the major soil types is being obtained.

Investigations on the effect of cover plants on tree growth and soil conditions are proceeding, and a complementary programme of research into methods of weed control is also being carried out. This work and that on fertiliser use in immature rubber is intended to determine the most economic methods by which a vigorous stand of rubber may be established. The work is important because effects produced during immaturity are likely to influence tree performance for some considerable time after tapping has commenced.

Supporting work carried out by the Division to provide background information on the major projects include pot culture investigations and constant adaptation of laboratory analytical techniques so that the large amount of analytical work accruing from the field investigations can be efficiently dealt with.

RESEARCH

MANURING OF HEVEA

Forty-six experiments were in progress at the end of 1961. During the year, four experiments were started and five terminated. Of the latter, two were the last of the old series of experiments started before the war on estates throughout the country. The only remaining trial which has been continued since that time is the one in Field 31 at the Experiment Station (SE.1/4). This is now being tapped on a high cut and will be continued for a few more years. Two other experiments terminated were on immature rubber and were discontinued on opening for tapping.

In co-operation with Botanical Division some small scale experiments were initiated to determine how methods of planting may be improved. Germinated seedlings were planted in polythene bags filled with different mixtures of soil, peat and cattle manure to which various rates of organic and inorganic fertilisers have been applied, and their growth is being followed.

Three experiments in immature rubber were commenced. One, a short term experiment (SE.1/30) incorporates different types and methods of fertiliser application in the planting hole, and different rates of fertiliser applied up to the budding

stage. The other two experiments (SE.60 and SE.36/2), on estates in Kedah and Malacca, are to test the effects of different levels of nitrogen and phosphate fertiliser applications on trees grown in association either with leguminous creeping covers or with grass covers.

A 3^3 manganese/magnesium/nitrogen experiment was laid down on a manganese-deficient area of ten-year-old rubber growing on soils derived from the 'Older Alluvium' typical of south Johore.

The Effect of Fertilisers on Growth

Immature rubber. In a series of three trials on coastal clay soils which have now been continued for two years from budding, the only responses measured have been to nitrogen fertilisers. No difference has been found in the effects of urea and ammonium sulphate indicating that these fertilisers are of equivalent value on coastal clay soils when applied directly to the soil surface in the planting row (*Table 1*).

TABLE 1. EFFECTS OF NITROGEN ON TREE GROWTH ON COASTAL CLAYS (GIRTH INCREMENTS IN CM)

(a) Nov. '60 to May '61. (b) May to Nov. '61

Experiment	SE.54		SE.55		SE.7/2	
	a	b	a	b	a	b
Control	5.506	6.582	6.058	6.324	4.757	4.596
Ammonium sulphate	5.306	6.566	6.200	6.510*	5.259*	5.083*
Urea	5.388	6.538	6.343	6.593*	5.294*	5.063*

* significantly different from the control at 5% level.

On inland soils, the main response measured has been to nitrogen and phosphate fertilisers with variable response to potassium and magnesium fertilisers.

Mature rubber. In the four replicated trials laid down in 1959 and 1960 to test treatments based on a 'Physiological Diagnosis' according to the method of E. R. Beaufils, no measurable effects on growth due to applications of phosphate (as rock phosphate and ammonium phosphate), potassium, copper or manganese have been observed. In one experiment, SE.57, on a granite-derived soil, tree growth was significantly increased after two annual dressings of $1\frac{1}{2}$ lb per tree of ammonium sulphate, while in another, SE.38/4, on inland sandy alluvium, growth was significantly improved after a total application of $1\frac{1}{2}$ lb per tree of kieserite (magnesium sulphate) over 1960/61, both with ten-year-old trees.

Increases in rate of tree growth due to the application of ammonium sulphate were recorded in two other experiments (SE.28/3 and SE.29/2) on ten- to twelve-year-old rubber three years after the first experimental treatments were applied. Both experiments are sited on inland sandy loams derived from shale. The potash response reported last year in one of these experiments was not maintained.

The Effect of Fertilisers on Yield

The results of measurements of plot yields in sixteen experiments throughout the year emphasise a fact not always appreciated, namely that yield is not measurably affected in a short period by fertiliser applications to young mature areas—even when the trees are deficient in some nutrient. In nine of the experiments which were started within the last four years, no statistically significant effects have been measured although in the same experiments effects on growth are present. This growth increase will of course have a favourable effect on future yield of the trees.

In the other seven experiments the pattern of yield responses to fertilisers was not consistent, but positive responses to the application of ammonium sulphate were recorded in three experiments.

The Effect of Fertilisers on Seed Production

Measurements of seed fall have been continued in three manuring experiments. The application of nitrogen increased seed numbers by up to 30% in one experiment sited on a coastal clay soil (SE.44), and by up to 100% on another experiment sited on a shale-derived inland soil (SE.28/3). No effects due to phosphate or potassium fertilisers could be measured. In the trial on coastal clay there was an indication that, during the period of maximum seedfall, nitrogen had also increased the percentage of seed germinating. Germination measurements in the other experiment, however, did not indicate any such effects on viability or on seed weight or size.

Detailed records of seedfall have been collected every week throughout the year in one experiment sited in a five-clone seed garden (SE.1/21). These show quite clearly that the seed which is available for autumn planting is only a fraction of the total available throughout the year (*Table 2*).

TABLE 2. MONTHLY SEED PRODUCTION IN 1961. EXPERIMENT SE.1/21

	1961										1962		Total
	Feb.	Mar.	Apr.	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	
Seeds per acre*	6214	2314	3653	2899	1664	2977	10,023	8658	3159	507	1950	3393	47,411
% of total	13.1	4.9	7.7	6.1	3.5	6.3	21.1	18.3	6.7	1.1	4.1	7.1	100

* Using 100 seeds/lb as a conversion factor. Seed weights were actually recorded but numbers are given for convenience.

As an ancillary project, measurements of seed weight, size and percentage germination have been made in several seed populations. As might be expected, large differences in these parameters were found between mother clones. Within a single population of seed from a PB 86 monoclone area there were highly significant correlations between seed weight and seed size and between seed weight and viability, the latter ranging from 100% to 20% for the high to low weight categories respectively.

The Effect of Fertilisers on Wind Damage

Wind damage has been severe in a fertiliser experiment (SE.52) on poorly grown RRIM 501, with a mean tree girth of 19 in. at two years after opening for tapping,

sited on granite-derived soil; the first experimental treatments were applied in 1959. Tree counts have shown a highly significant increase in tree losses resulting from the annual application of 2 lb per tree of ammonium sulphate but not from the application of phosphate, potassium or magnesium fertilisers. Figures are given in *Table 3* of the mean tree losses from 1959 to 1961.

TABLE 3. TREE LOSSES IN 1959–61 PER PLOT (0.8 ACRES) OF RRIM 501, BUDDED 1951, TAPPED 1956. EXPERIMENT SE.52

Control	5.71	Control	8.54	Control	7.67	Control	8.91
N	10.83**	P	8.00	K	8.87	Mg	7.62

** significant at $p < 0.01$

These results confirm those reported by Rosenquist at the Natural Rubber Research Conference, 1960, and show that applications of nitrogen to young mature RRIM 501 in a wind damage susceptible condition are inadvisable.

CULTIVATION AND GROUND COVERS

Weed Eradication

The programme of investigations into the problems of weed control can be considered in two sections: the testing of promising new herbicides as they appear, and the use of these and already proved herbicides, either alone or in mixed formulations, in field problems of weed control.

Seventy-one experiments were laid down in 1961 of which thirty-eight were completed. A point quadrat method of recording herbicidal effects with regard both to total ground cover and effects on individual species, suitable for the type of weed populations encountered in rubber cultivation, was devised at the beginning of the year. All effects were recorded by this method.

New Herbicidal Compounds

Paraquat. Paraquat is an organic chemical (1,1′-dimethyl,4,4′-bipyridylium-dimethyl sulphate) that has been very effective as a contact herbicide in field trials and was reported in *Annual Report 1960* under the code name PP 910. Paraquat is marketed as a liquid formulation containing 2 lb of active ingredient per gallon. Applied at the rate of 0.4 gal. per acre it has proved very effective against *Axonopus compressus, Mimosa pudica, Panicum nodosum, Digitaria longiflora, Scleria laevis* and *S. hebecarpa,* the last four species being particularly sensitive. Applications at the rate of 0.5 – 0.6 gal. per acre have given effective control of *Paspalum conjugatum* and *Tricholaena rosea,* but *Cyperus rotundus* and *C. sphaceolatus* have proved resistant to Paraquat.

Simazine, Atrazine, Prometone, Atratone and Prometryne. These chemicals are of value as pre-emergence herbicides, belong to the triazine group of organic compounds and have the following composition:

Simazine — 2-chloro-4,6-bis(ethylamino)-1,3,5-triazine.
Atrazine — 2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine.
Prometone — 2,4-bis(isopropylamino)-6-methoxy-1,3,5-triazine.

Atratone — 2-ethylamino-4-isopropylamino-6-methoxy-1,3,5-triazine.
Prometryne — 2-methylmercapto-4,6-bis(isopropylamino)-1,3,5-triazine.
All are available as wettable powders containing 50% active ingredient.

All have been tested at rates of application of 5 and 10 lb per acre in 50 gal. of water for their ability to maintain weed free conditions in initially clean-weeded planting strips. On a sandy soil no difference in effect was observed between the different rates of application, some three months' extension of control compared with hand weeding being obtained with Simazine and Atrazine and approximately 5 months' with Atratone and Prometone. No increase in the effect of Simazine and Atrazine was found by applying at rates of 15 lb per acre.

Prometone and Atratone have both been shown to be significantly more active than Simazine and Atrazine as pre-emergence herbicides; Prometryne has also shown promise in preliminary trials and work is continuing on all these chemicals.

Amitrole (50% a.i.) has been shown to have some pre-emergence herbicidal effect, and its admixture at 5 lb per acre to an application of 5 lb per acre of Simazine considerably increased the latter's effect in an area where *Paspalum conjugatum* was the main weed. In similar trials with dalapon/Simazine mixtures no such effect could be recorded.

Miscellaneous herbicides of the pre-emergence type tested during the year included members of the substituted urea, substituted benzoic acid and benzonitrile groups of compounds. Those that have shown promise are being selected for further work.

Control of Mixed Weed Populations

Previous work (*Annual Report 1959*) showed that dalapon (74% a.e.) is effective against *Axonopus compressus* but not against *Paspalum conjugatum*, while the reverse is true for amitrole. Further detailed study of mixtures of the two herbicides, applied at rates of 2.5, 5, 7.5 and 10 lb per acre of each chemical (Experiments PR.6 and PR.30) have revealed a synergistic effect between the two herbicides when sprayed on *Axonopus compressus*, and an antagonistic effect when sprayed on *Paspalum conjugatum*.

In trials on the control of weed populations containing *Paspalum conjugatum*, *Scleria spp.* and *Mikania scandens* as the main weeds, good control was obtained with applications of either 0.5 gal. of Paraquat per acre or of a mixture of 25 lb sodium chlorate and 4 lb per acre of amitrole. This and other work has confirmed the value of the latter mixture as a general herbicide. Dalapon, lallicide and amitrole alone, were generally less effective.

Experimental work, and general observations, show that in a mixed weed population the presence of *Mikania scandens* can adversely affect the efficiency of a herbicidal spray since its leaves intercept much of the spray. It has been found that if *Mikania scandens* is first eliminated by spraying with 2,4,–D (Fernoxone), which is cheaply available, then the effectiveness of subsequent application of herbicides against the other weed species present is much increased. This is of importance when expensive herbicides are to be used.

Weed Control in Legume Covers

Pre-emergence herbicides may prove of value in the control of weed seeds germinating in developing legume covers. The herbicides are applied soon after the

Figure 1. Experiment SE.4/2. Trees in 'Legumes' plot which received a normal schedule of NPK fertiliser application, at 2½ years after budding.

Figure 2. Experiment SE.4/2. Trees in 'Mikania' plot which received a normal schedule of NPK fertiliser application, at 2½ years after budding.

legume seedlings have germinated, but care must be taken not to spray either the legume seed drills or the legumes themselves for damage may ensue. In field trials legumes were damaged by pre- and post-emergence applications of 1 lb per acre of dalapon, amitrole, Simazine, Atrazine, Prometone and Atratone. Further studies are being directed towards finding pre-emergence herbicides that will not damage the legumes.

Methods of Application

There is much room for improvement in the methods of applying herbicides in rubber plantations and the matter is receiving attention. Only preliminary work could be carried out in 1961 but further studies are being developed.

Volumes of application. It has been commonly thought that the greater the quantity of spray liquid applied the better the effect likely to be obtained. This is not necessarily so and excessive run-off when applying expensive herbicides needs to be avoided as wasteful. Four experiments were carried out testing the effect of standard amounts of dalapon, Paraquat, and amitrole/dalapon mixtures on grasses and grass/legume mixtures, when sprayed in volumes of 100, 70, and 40 gal. of water per acre. Spraying at 40 gal. per acre was as effective as spraying at 100 gal. per acre, provided the same nozzle tip was used, and 40 gal. per acre may be taken as a suitable volume of application to grass and herbaceous weed populations.

Comparison of Leguminous and Non-leguminous Covers and Their Effects on Tree Growth

The five large scale cover plant experiments have reached an interesting stage, with clear effects on tree growth apparent and two experiments likely to come into tapping in 1962. Details of these experiments are given in *Table 4*, and girth recordings taken at the end of 1961 are given in *Table 5*.

In each experiment the best growth has been shown by trees grown together with leguminous creeping covers. The effect is small and non-significant in experiment SE.48/3 sited on coastal alluvium, but major differences are shown in the experiments on the inland soils. In these experiments the trees in the 'Legume' treatments are showing vigorous growth and carry much heavier leaf canopies than do trees in the non-legume treatments (see *Figures 1* and *2*). Trees in the 'Grass' treatments come second in order of vigour while those in the '*Mikania*' and 'Naturals' treatments come last. Covers in the 'Naturals' treatments consist of vigorous stands of indigenous bushes, ferns and creepers and might be expected to compete severely with the rubber tree for soil moisture and nutrients, but the depressive effect of *Mikania scandens* is less easy to understand. Some small scale work in pot-culture is being carried out to obtain further information on the characteristics of this plant.

These experiments have now progressed sufficiently far to enable *Mikania scandens* to be recognised as an undesirable weed species. It is also apparent that trees in the 'Legume' treatments will come into tapping well in advance of those in the other treatments and it will soon be possible to make an accurate estimate of this earlier time to maturity to be taken into account when comparing the costs of the different cover plant regimes. An important point in this respect can be seen on reference to *Table 5:* in experiments SE.28/2, SE.1/22 and SE.4/2 on inland soils, trees in the 'Nil' fertiliser plots of the 'Legume' treatments (where no

TABLE 4. LARGE SCALE COVER PLANT EXPERIMENTS

Experiment	Date of planting/budding planting material	Soil type	Treatments
SE. 1/17 (23)†	Replanted October, 1957 budded December, 1957 RRIM 603	Alluvial sand (Sungei Buloh series)	Leguminous creepers Grasses *Mikania scandens* Fertiliser* applied to rubber or to cover
SE. 48/3 (S.R.)	Replanted November, 1956 budded January, 1959 GT 1	Coastal alluvial clay (Selangor series)	
SE. 28/2 (S)	Replanted October, 1957 GG 1 seedling stumps	Loam (Seremban series)	Leguminous creepers Grasses *Mikania scandens* Naturals
SE. 1/22 (63A)	New planted December, 1957 Tjir 1 seedlings	Sandy clay loam (Rengam series)	With and without fertilisers* Fertiliser applied to rubber or to covers
SE. 4/2 (B)	Replanted September, 1958 budded September, 1959 RRIM 623	Loam (Seremban series)	

† Numbers in brackets are the numbers by which these experiments were referred to in the paper on 'Cover Plants and the Soil Nutrient Cycle in *Hevea* Cultivation' at the Natural Rubber Research Conference, 1960.

* Where fertiliser has been applied, applications have been according to the schedule given in *Planters' Bulletin 35*, using Mixture M fertiliser (NPK).

Experiments SE. 1/17 and SE. 48/3 are in quadruplicate, the others being in triplicate.

TABLE 5. EFFECT OF COVER PLANTS ON TREE GIRTH (IN INCHES)

Experiment	Years after planting† or budding*	Cover plant	Treatment				s.e. and min. 5% sig. difference	
			Nil fertiliser (i)	Fertiliser to rubber (ii)	Fertiliser to covers (iii)	Mean	Cover means	Fertiliser effect over all covers (difference between (i) and mean of (ii) and (iii))
SE. 1/17	4*	Legumes	—	15.53	14.14	14.84	± 0.274	—
		Grass	—	13.77	11.73	12.75	0.826	—
		Mikania	—	13.46	12.12	12.79	$p < 0.001$	—
		Mean		14.25	12.66		(2df)	
SE. 48/3	3*	Legumes	11.52	12.04	11.89	11.74	± 0.111	± 0.092
		Grass	11.46	11.84	11.49	11.56	0.355	0.262
		Mikania	11.33	11.57	11.43	11.41	N.S.	$p < 0.05$
		Naturals	11.27	11.46	11.40	11.35	(3df)	
		Mean	11.39	11.73	11.55			
SE. 28/2	4†	Legumes	14.40	15.45	15.17	14.86	± 0.2940	± 0.153
		Grass	13.44	13.83	13.69	13.60	1.0172	0.444
		Mikania	11.83	13.13	11.48	12.07	$p < 0.001$	$p < 0.01$
		Naturals	11.05	12.42	12.51	11.77	(3df)	
		Mean	12.68	13.71	13.21			
SE. 1/22	4†	Legumes	14.60	14.84	14.97	14.75	± 0.228	± 0.128
		Grass	13.39	14.26	13.59	13.66	0.789	0.370
		Mikania	13.15	13.20	13.59	13.27	$p < 0.05$	$p < 0.1$
		Naturals	13.32	13.49	13.52	13.41	(3df)	
		Mean	13.62	13.95	13.92			
SE. 4/2	2*	Legumes	9.15	9.30	8.96	9.14	± 0.163	± 0.045
		Grass	8.65	9.00	8.76	8.76	0.568	0.130
		Mikania	7.01	7.27	7.07	7.09	$p < 0.001$	$p < 0.05$
		Naturals	7.83	7.98	8.01	7.91	(3df)	
		Mean	8.16	8.39	8.20			

fertiliser has been applied after the first year of growth) have grown better than trees in any of the other cover plant treatments even where these have received full fertiliser applications. It seems probable that the use of leguminous creepers may permit economies in fertiliser usage, particularly when soil conditions are good. This point has been elaborated upon in an article 'Cover Plants, Manuring and Wind Damage' in *Planters' Bulletin 57*, 1961, which quotes data on the nutrient content of leguminous creeping cover plants.

Leguminous covers and their effect on leaf nutrient content and weight of litter. Leaf samples have been taken from trees in all the above experiments, and analysis has shown that those from the 'Legume' treatments contain higher levels of nitrogen than do those from the other cover plant treatments. To obtain an indirect measure of the effect that legume covers have on the total weight of leaves, leaf litter collections in the different plots of Experiment SE.1/17 have been carried out. Over a period of three months, at the end of the year, i.e. four years after budding, approximately four times as much leaf litter per tree was collected in the 'Legume' treatments as compared with that collected in the 'Grass' and '*Mikania*' treatments. This work is being continued.

The effect of cover plant treatment on surface rooting by Hevea. Determinations have been carried out, in Experiment SE.1/17, of the density of *Hevea* feeding roots above the soil surface (in the cover plant litter) and in the top three inches of soil, in the different cover plant treatments. Results given in *Table 6* confirm visual observations in showing that there is a much greater weight of *Hevea* feeding roots in the cover plant litter and top three inches of soil in the 'Legume' treatments than in the others. Since the mulch and surface soil layers are the most fertile sections of the soil profile the greater vigour and nutrient uptake by trees in the 'Legume' treatments can be understood.

TABLE 6. HEVEA FEEDING ROOTS ABOVE SOIL SURFACE AND IN 0–3 INCHES LAYER OF SOIL (EXPERIMENT SE.1/17)

(in g/sq. yd. of surface area)

Treatment	Above surface	0–3 in. soil layer
Legumes	11.84	31.16
Grass (*Paspalum conjugatum*)	1.74	18.70
Mikania	1.11	15.77

Statistical analysis after logarithmic transformation, shows that the mean weight of 'above surface' roots and roots in the 0–3 in. layer in the 'Legume' treatments is significantly greater than that for 'Grass' or *Mikania* treatments at levels of $p < 0.001$ and $p < 0.05$ respectively.

The effect of cover plant treatment on soil nitrogen status. It has been possible to devote rather more time to soil sampling in the large and small scale cover plant experiments. After a preliminary statistical study it has been possible to develop satisfactory sampling techniques. Data obtained in periodical sampling in Experiment SE.1/17 and Experiment SE.1/28 (a small scale experiment involving 0.01 acre plots of bare soil, leguminous creepers, grasses and natural covers) and given in *Table 7*, show that higher levels of nitrate nitrogen are found under covers

TABLE 7. NITRATE-NITROGEN CONTENT IN SOIL UNDER DIFFERENT COVER PLANTS (p.p.m.)

Experiment	Treatment	Depth, inches	Date of sampling						
			6/3/61	11/5/61	10/7/61	1/9/61			
SE. 1/17	Legumes	0—6	3.75	3.55	5.29	4.29			
		12—18	2.24	1.19	1.90	2.73			
	Grasses	0—6	1.52	1.06	1.12	2.61			
		12—18	1.05	0.55	0.58	2.27			
	Mikania	0—6	0.55	0.62	0.50	2.13			
		12—18	0.35	0.33	0.23	1.67			
	s.e. of cover means at the same depth		± 0.230	± 0.228	± 0.3572	± 0.405			
	Min. 5% sig. diff.		0.69	0.69	1.077	1.22			
			6/4/61	8/5/61	5/6/61	6/7/61	3/8/61	8/9/61	6/10/61
SE. 1/28	Legumes	0—6	3.53	4.88	4.17	4.66	7.31	5.30	5.75
		12—18	2.35	3.54	3.07	3.24	6.70	4.82	5.43
	Grasses	0—6	1.48	1.19	1.16	2.14	5.15	5.33	4.46
		12—18	2.03	1.54	1.12	1.66	3.84	4.92	5.80
	'Naturals'	0—6	1.70	3.46	6.63	4.18	4.83	4.01	4.20
		12—18	2.20	2.59	3.13	2.84	5.06	4.57	7.15
	Bare soil	0—6	9.63	12.09	16.92	21.91	33.83	28.57	36.90
		12—18	24.08	30.91	30.18	34.80	43.13	37.79	44.14
	s.e. of cover means at the same depth omitting 'Bare Soil'		± 0.6947	± 0.4840	± 0.5115	± 0.6544	± 0.7140	± 0.738	± 0.9721
	Min. 5% sig. diff.		2.40	1.67	1.77	2.26	2.47	2.55	3.36
	s.e. of depth means for 'Bare Soil' only		± 1.989	± 1.809	± 0.830	± 0.819	± 1.267	± 1.790	± 1.966
	Min. 5% sig. diff.		8.95	8.14	3.74	3.69	5.70	8.06	8.85

of leguminous creepers than under non-leguminous covers, in particular grass and *Mikania*. Levels of ammonium-nitrogen are similar. These are consistent factors borne out by further sampling being carried out in large scale cover plant experiments, and are of importance when it is considered that a concentration of 1 p.p.m. of nitrate nitrogen in the 0 – 6 in. soil layer is very approximately equivalent to 10 lb per acre of ammonium sulphate fertiliser.

Preliminary data from other samplings suggest that legume covers also increase the organic matter and total nitrogen contents of the soil, and in three experiments the surface layer of soil under leguminous creepers has been found to have a lower C/N ratio than soil under grass, *Mikania* or natural covers. In laboratory incubation tests with these soils, carried out over periods of 28 days, higher rates of nitrification have been found in soils from 'Legume' plots than in soils from non-legume plots.

The sampling from Experiment SE.1/28, which is sited on an area cleared from jungle in 1960, has confirmed that very high nitrate-nitrogen levels develop under bare surface soil conditions, and the difference in concentration between the 0 – 6 in. and 12 – 18 in. samples suggests that the nitrate is being actively leached through the soil.

Small Scale Trials with Legumes

Further sampling has been carried out in trials studying the phosphate requirements of leguminous creeping covers. Interim results of some of this work were reported in the *Planters' Bulletin* article mentioned above.

SOIL INVESTIGATIONS

Soil Types Under Rubber Cultivation

With the clearing of new land for rubber cultivation and the appearance of nutritional problems subsequent to replanting, it has become necessary to obtain a better appreciation of the different soil types under rubber cultivation so that fertiliser recommendations can be made with greater discrimination than at present. It is possible that improvements in tree growth and yield will be obtained in this way, but a more likely benefit will be economies in fertiliser costs by using formulations more suited to particular circumstances than the general mixtures at present in use.

Any such study of the soils under rubber cultivation must include a study of the nutritional status of the trees, and the first stage in this work is to survey 472 sites involved in the work on 'Physiological Diagnosis'. Leaf analysis and yield data are available from these sites and they are now being classified according to soil type to determine what relationship may exist between the tree nutritional status and its yield. One hundred and sixty soil samples have been drawn from fifty selected sites and fully analysed, determinations of total and exchangeable calcium, magnesium and manganese (on which few data are available) being included.

Soils of South Johore. A previous *Annual Report* (1958) has recorded a higher incidence of manganese deficiency in south Johore than in other parts of the country and there have been suggestions of the occurrence in the same area of a geological series of sedimentary material known as 'Older Alluvium'.

Examination of soil pits and exposures, in collaboration with staff of the Department of Agriculture and the Geological Survey, in several areas has shown that

there is a link between the occurrence of manganese deficiency and the 'Older Alluvium' deposits. It is sometimes difficult to distinguish these soils from granite soils *in situ* (Rengam series) and in these cases the only diagnostic features are the presence of rounded quartz pebbles and in some cases a light yellow-red mottling of the sub-soil. Analyses and pot tests with samples of soil from these areas show them to contain very low levels of most plant nutrients.

In these areas of South Johore where the old rubber trees are clearly more stunted than most other parts of the country, the poor growth has usually been explained by the comparatively long period over which the soils are said to have been cultivated. It now seems that the derivation of these soils from a parent material in its second cycle of leaching and erosion may be the main factor.

As already mentioned, a manganese fertiliser trial has been sited on a typical area of these soils (SE.59).

Use of the Subtractive Technique for Assessing Soil Nutrient Status

The 'subtractive technique', first mentioned in last year's Report, offers a bio-assay method of comparing the nutrient status of soils, in order to supplement soil analyses and to help in their interpretation. Twenty soils have been tested by this method and the results compared with those obtained by chemical analysis.

In comparisons of the Kuantan and Segamat series soils, both derived from basic volcanic rocks and having high levels of 'total' phosphate, both methods showed a much higher level of 'available' phosphate in the former than in the latter. The subtractive technique also confirmed that a soil derived from the 'Older Alluvium' of south Johore contained only low levels of phosphate and potassium, magnesium, calcium and manganese.

Leaching of Soil Nutrients and of Fertilisers Through the Soil

A further lysimeter study has been completed, in which the effect of broadcast surface dressings of ammonium sulphate, mono-calcium phosphate, potassium chloride and limestone on the leaching of nutrients was tested. Eighteen lysimeters were used for the different treatments and each was leached with approximately one inch of rainwater each week for five months.

The same pattern of leaching took place as was reported last year for the first experiment. Analyses of the different soil horizons sampled at the termination of the experiment were not complete at the end of the year; they have shown however that only slight leaching of mono-calcium phosphate (superphosphate) took place in this short term experiment.

Loss of Ammonia From Surface Dressings of Urea Fertiliser

Urea fertiliser, containing 45% of nitrogen, has a potential economic advantage over ammonium sulphate (21% nitrogen) and moreover exerts a less acidifying effect upon the soil. It has been shown elsewhere however, that under certain conditions surface dressings of urea fertiliser decompose to release ammonia gas which may be lost to the atmosphere. This loss may be high enough to offset the economies obtained by using urea and work has been carried out to determine the possible level of ammonia losses from surface dressings of urea applied in rubber plantations.

Little loss of ammonia was found from urea applied to the surface of Selangor series alluvial clay soil, and from urea applied to sands and sandy loams when

in a dry condition. Losses of only 10% of the applied nitrogen were determined after application to soil saturated with moisture, but losses of up to 24% were recorded after application to loams and sandy loam soils that were just moist enough to promote the decomposition of the urea and yet not wet enough to absorb any appreciable proportion of the fertiliser.

It was concluded that urea fertiliser can safely be used on alluvial clay soils at all times. Urea may be applied to the surface of loam and sandy loam soils when in a dry condition with little risk of appreciable loss, but it should only be applied to such soils when moist if the fertiliser is to be forked in.

A summary of the results together with recommendations was published in an article 'Loss of Ammonia from Surface Applications of Urea Fertiliser' in *Planters' Bulletin 57*.

Pot Culture Studies on Phosphorus Uptake

Three pot experiments with rubber seedlings have been carried out, using a Kedah series sandy loam in two of the experiments and a Sungei Buloh series sandy soil in the other.

One experiment using Kedah series soil was designed to compare rock phosphate with superphosphate in the presence and absence of other nutrients, and results obtained differ from previous results with this soil type in that rock phosphate was found to be superior to superphosphate. In this experiment, however, plants grown with superphosphate had been affected by a form of terminal die-back which checked their growth and produced abnormal side-shooting; this effect invalidated the comparison to some extent. Similar symptoms of abnormal growth have been observed in the field (at R.R.I.E.S. and on two estates) and it seems that they may be associated with soluble phosphates and with excessively wet conditions or poor drainage.

The pot experiment in Sungei Buloh soil has been carried out at the same time as a corresponding experiment on the same soil type at the Experiment Station. In both experiments, rock phosphate and superphosphate have been compared, using different methods and levels of application for both phosphates. A supplementary fertiliser mixture containing nitrogen, potassium and magnesium was also applied; half the treatments received a minor element supplement, while half of them did not. Growth of plants receiving phosphates has been comparable for both experiments with no significant difference between the two fertiliser types, but control plants in the field have grown far more than those in pots. Although preliminary tests had indicated a deficiency of phosphate, a marked growth response has been obtained from phosphate applications in pots but not in the field.

Soil analyses carried out in the pot experiments have again demonstrated that superphosphate moves appreciably downward through a soil column, when repeatedly leached with water. The effect is greatest when superphosphate is applied in pockets but for rock phosphate the leaching effect is very small irrespective of the method of applying the fertiliser.

PLANT INVESTIGATIONS

The Mineral Composition of Foliage and Latex of Trees in Production

Effect of fertilisers. The detailed investigations of the effects of ammonium sulphate, potassium chloride and rock phosphate applications on the mineral com-

position of leaves and latex have been continued in the three experiments (SE.1/10, SE.1/21, SE.29/2) first described in the *Annual Report 1958*, and the same main effects of these fertilisers have again been observed in 1961. These effects have also been confirmed in leaf and latex sampling in two other fertiliser experiments, the first, a factorial 3^3 NPK experiment (SE.28/3, PB 86, 1948 replanting), and the second, a factorial 2^4 NPKMg experiment (SE.52, RRIM 501, 1950 replanting).

During 1961 further effects of ammonium sulphate, potassium chloride and rock phosphate on tree nutrient status have been observed in the above experiments, and the effects of magnesium fertilisers on leaf and latex composition have been of particular interest.

Kieserite and magnesium limestone. A significant positive effect of kieserite (magnesium sulphate) on leaf magnesium, and a significant negative effect on leaf potassium has been observed in Experiment SE.52 sited on a granite-derived soil. Significant positive effects of magnesium limestone on leaf and latex magnesium and on latex phosphorus and significant negative effects on leaf potassium, nitrogen, phosphorus and manganese were observed in an experiment on mature rubber suffering from acute magnesium deficiency (SE.32); this experiment has been reported in a paper by Bolton and Shorrocks (1961) in the *Journal of the Rubber Research Institute of Malaya*, Vol. 17, p. 31.

Trace elements. Investigations on the effects of applications of manganese sulphate, copper sulphate and sodium molybdate on leaf and latex nutrient composition have been continued (Experiments SE.1/21(i) and (iii) and SE.1/25). The effects of soil applications of manganese sulphate on the manganese status of the tree have been reported in a paper by Shorrocks and Watson (1961) in the *Journal of the Rubber Research Institute of Malaya*, Vol. 17, p. 19.

Determining Fertiliser Requirements

Leaf sampling procedure. The studies on leaf sampling technique for mature trees have almost reached completion. It has been concluded from these investigations that the sampling of leaves taken from terminal whorls in the shade of the canopy, and which are borne on low branches, is a convenient method of sampling and also one that provides a sensitive index of the nutrient status of the tree.

The effects of ammonium sulphate, rock phosphate, potassium chloride, manganese sulphate and copper sulphate applications on the nutrient composition of leaves exposed to full sunlight, on leaves in the shade of the canopy of low branches, and on leaves borne on branches of limited growth, such as are employed in the method of Physiological Diagnosis in use in Vietnam, have been studied.

Differences in the magnitude of the effects of these fertilisers on the nutrient composition of the three leaf types were found. Shaded leaves collected from low branches were found to be more sensitive to changes in nitrogen and phosphorus status, and less sensitive to changes in the magnesium and calcium status than leaves exposed to full sunlight. Little difference in the sensitivity to changes in potassium, manganese and copper status was found between shaded and exposed leaves.

On the basis that the leaf type which is more sensitive to changes in the nutrient composition imposed by treatment is likely to be the one that reflects more clearly the current nutrient status of the tree, it is concluded that shade leaves are to be preferred to leaves exposed to full sunlight in investigations on the mineral nutrition

of *Hevea*. Leaves exposed to full sunlight may be preferable to shade leaves when studying, in particular circumstances, the magnesium and calcium status of the tree.

Studies have also been made on the tree to tree variation in the nutrient content of the different leaf types, on the effects of storage prior to drying on leaf dry weight and nutrient concentration, and on the nutrient composition of leaves analysed with and without midribs.

The Method of 'Physiological Diagnosis'

A total of twenty-one experiments have been carried out, on a task plot basis, to investigate the validity of the method of 'Physiological Diagnosis' for determining the fertiliser requirements for mature rubber: nine of these experiments have been in progress for almost two years, eight experiments for eighteen months and five experiments for almost one year. In all these trials one of the treatments employed was based on the results of the physiological diagnosis, and where this was different from the fertiliser treatment that would otherwise have been used the latter fertiliser constituted another treatment.

No significant increases in yield have been observed following the application of fertilisers according to the method of 'Physiological Diagnosis' in any of the twenty-one experiments. This situation is in marked contrast to that reported in Vietnam, where it was claimed that substantial yield increases were observed in periods up to six months after the application of fertilisers based on physiological diagnosis. The difference might be due to the absence of any marked nutrient deficiency in the experimental areas, or to the difficulties encountered when using the diagnostic method, as outlined in *Annual Report 1960*, but as a consequence the majority of the experiments designed to test the method of 'Physiological Diagnosis' have been terminated.

Relationship between Nutrient Status and Growth and Yield

Investigations into the relationships between tree nutrient status and growth and yield, in experiments started in 1957 and 1958, are now starting to provide results, with growth responses to the applications of fertiliser beginning to appear.

It is now possible from these experiments to recognise tentatively the following nutrient levels for leaves exposed to full sunlight on mature rubber trees (*Table 8*).

TABLE 8. PERCENTAGE NUTRIENT CONTENT IN LEAVES EXPOSED TO FULL SUNLIGHT

	Nutrient level below which response likely	Nutrient level above which no response likely
% Nitrogen	3.40	3.60
% Phosphorus	0.21	0.25
% Potassium	1.00	1.40
% Magnesium	0.23	—

A further study is being made of the relationship between the nutrient status of shade leaves and tree growth and yield, in an endeavour to define similar nutrient levels for shade leaves.

Variation in Leaf Nutrient Composition with Age of Leaf

A study has been made of the variations in leaf nutrient composition with age of leaf, on mature trees of clone RRIM 501. Whorls of leaves, situated in the shade and also at the top of the canopy in full sunlight, were labelled at the time of their development, in order to provide a means of identication. In this way it was possible to collect leaves of known ages for analysis, and one such collection of leaves was carried out when the age of the oldest known leaf was nineteen weeks. Preliminary assessment of the results indicates that the variations in nutrient composition with age of leaf are not clearly defined. Whereas increases in the calcium and manganese contents and decreases in the potassium content follow a consistent trend with age of leaf, the variations in leaf nitrogen, magnesium and phosphorus do not appear to do so. A detailed study of these results will be carried out on the completion of the nutrient analysis of leaves collected at a time when the age of the oldest known leaf was forty-one weeks.

Observations on the development of new leaves on branches in the shade and branches in full sunlight, indicate clearly that whereas sporadic leaf development on branches in full sunlight took place throughout the whole period of the investigation, the development of leaves on branches in the shade of the canopy was restricted to a short period of time after wintering.

Brown Bast Investigations

Investigations into the problem of brown bast commenced in the latter part of the year, in consultation with the Botanical and Pathological Divisions.

Two experiments (SPD.151/1 and SPD.151/2) on PBIG seedlings (1948 replanting) situated on a granite-derived soil, were commenced in order to determine whether there is any difference between the incidence of brown bast on trees tapped upwards and that on trees tapped downwards, and also to determine whether the boron nutrition of the tree is likely to be an important factor. This work is still in progress.

The Nutrient Cycle of the Rubber Plantation

Results from several research projects are being collected to enable a picture of the nutrient cycle of the rubber plantation to be drawn. Data on the nutrient content of whole trees of different ages, on the mobilisation of nutrients by cover plants and on the effects of fertilisers on nutrient retention and leaching in the soil, are being obtained. A complementary study to this work has begun in the periodic collection of dead wood and leaf litter from under two stands of Tjir 1 rubber, 13 and 32 years old respectively, at the Experiment Station. The collected material is being analysed to obtain some estimate of the annual return of nutrients to the soil.

LABORATORY INVESTIGATIONS

Methods of Analysis of Soil and Plant Material

The main object of this work is to modernise and improve existing R.R.I. laboratory methods; a subsidiary aim, for plant analysis, has been to compare and co-ordinate results with those obtained by other research laboratories in Malaya.

Soil analysis. Rapid and sensitive methods for the determination of mineralised nitrogen, i.e. nitrate and ammonium, have already been modified to suit local conditions and are in routine use.

A new and rapid method for the determination of exchange capacity has been worked out and is now being compared with a standard method.

More convenient methods for the determination of total and exchangeable bases are also being investigated in order to meet the increased demand for data of this type.

Plant analysis. The analysis of rubber leaf material for the major elements has been made more convenient by substituting dry ashing for wet digestion, and a new method for the determination of calcium and magnesium has now replaced our older methods for the determination of these elements. This work has been published in *The Analyst*, February, 1961, Vol. 86, p. 111.

A new rapid method for the determination of sulphur in plant material has been worked out and will be used in place of our current gravimetric procedure. The method is to be published in *The Analyst* in 1962.

A volumetric method for the determination of milligram amounts of rubber hydrocarbon will, it is hoped, be worked out shortly. Work is proceeding to apply it to the analysis of the various vegetative parts of the rubber tree.

ADVISORY

The Division was called upon to give a greatly increased number of lectures during the year. Three lectures were given to branches of the Incorporated Society of Planters, four were given to Senior Conductors' Courses and three to Assistant Rubber Instructors' courses at the Experiment Station. In addition five lectures and demonstrations were given during the training course for R.I.D.A., C.D.C., F.L.D.A. and Estate Assistants held in 1961, and four lectures were given to students from the College of Agriculture, Serdang. One lecture was given to a group of cadet planters on an estate, and the Head of Division lectured on 'Chemistry and the Cultivation of Rubber' at the Annual General Meeting of the Royal Institute of Chemistry in Singapore.

G. A. Watson
Head of Soils Division

Botanical Division

'The material which will obtain the principal share of the world's rubber demand is the material which is available at the most competitive price. A reduction in costs so that we can always supply demand at a stable price, even if need be at low level, should be our goal' (W. Anderson—Chairman of the Rubber Growers Association, 1960). The work of the Botanical Division is primarily aimed at this goal. The production of higher yielding planting material by breeding and selection; reduction of time of immaturity by applying new methods of propagation, planting and soil cover husbandry; increase in production per labourer by using suitable combinations of planting systems, task size, tapping systems and yield stimulants; all these are major items of the Division's research programme and have already led to considerable benefits to the rubber industry. Work is also in progress to prevent or reduce the effects of existing or threatening dangers such as wind damage, South American leaf blight and brown bast. With the increase of specialised senior staff, more emphasis has been placed in recent years on fundamental investigations the results of which are expected to yield improvements in approach to the research programme outlined above.

RESEARCH

BREEDING AND SELECTION

As in recent years, the main objects of the breeding programme were to establish one large family of about a thousand seedlings from a cross which is known from past experience to produce superior progeny, and to establish a number of exploratory families of about a hundred seedlings each, using a few selected parents in as many combinations as possible. The exploratory crosses which result in superior progeny will be repeated to produce large families in future programmes. The inbreeding programme was continued by selfing a number of well known clones.

Planning and Execution of Hand Pollination Programmes

A total of 30,139 pollinations was made between 6 March and 19 May. The results are shown in *Table 9*.

The large family chosen was RRIM 501 × 33/520; 7,479 pollinations were made with RRIM 501 as the female parent and 779 with 33/520 as the female parent; 1,016 seedlings were obtained.

7,304 exploratory crosses were made between clones PB 5/51, RRIM 600, RRIM 701 and 51/102.

The cross RRIM 612 × RRIM 628 which failed in 1960 was repeated and again failed. It seems probable that heavy loss of immature fruit is a clonal characteristic of RRIM 612.

The inbreeding programme was continued by selfing Tjir 1, RRIM 501, LCB 1320, PR 107, PB 86, RRIM 605, RRIM 527, RRIM 623, RRIM 628, RRIM 600 and S_1 seedlings of Lun N. Many of these clones are recommended

TABLE 9. RESULTS OF THE 1961 HAND POLLINATION PROGRAMME

Family	No. of pollinations	No. of fruits harvested	% of pollination success	No. of seeds planted	No. of seeds germinated	% of germination success
Tjir 1 selfed	1090	79	7.2	258	245	95.0
RRIM 501 selfed	1295	84	6.5	252	233	92.5
LCB 1320 selfed	1122	51	4.5	155	136	87.7
PR 107 selfed	1449	29	2.0	86	54	62.8
PB 86 selfed	954	28	2.9	84	83	98.8
RRIM 605 selfed	1343	53	3.9	162	135	83.3
RRIM 527 selfed	1400	19	1.4	53	30	56.6
RRIM 623 selfed	1161	21	1.8	64	55	85.9
RRIM 628 selfed	1501	55	3.7	158	145	91.8
RRIM 600 selfed	1919	27	1.4	85	85	100.0
Lun N S_1 selfed	114	—	—	—	—	—
PB 5/51×RRIM 600	1264	70	5.5	217	158	72.8
PB 5/51×RRIM 701	1455	186	12.8	565	497	88.0
RRIM 612×RRIM 628	1229	—	—	—	—	—
RRIM 600×51D/102	1522	48	3.2	153	147	96.1
RRIM 600×RRIM 701	1747	59	3.4	182	177	97.3
RRIM 701×51D/102	1245	—	—	—	—	—
51D/102×RRIM 701	71	2	2.8	6	6	100.0
RRIM 501×33/520	7479	354	4.7	1062	947	89.2
33/520×RRIM 501	779	25	3.2	70	69	98.6
Total or mean	30,139	1190	3.9	3612	3202	88.6

for inclusion in polyclone seed gardens and testing of their selfed progeny will help to evaluate their performance as parents.

Investigations into Hand Pollination

An experiment was carried out on trees of RRIM 501 to compare the success of hand pollination with that of natural pollination, and to check on the reliability of the method of hand pollination used. The treatments were:

(a) Hand pollination in the usual way.
(b) A procedure identical to (a) above, except that no staminal columns were inserted in the female flowers.
(c) Open pollination of inflorescences prepared as for hand pollination.
(d) Open pollination of inflorescences which were not interfered with in any way.

The number of female flowers or immature fruits remaining was counted daily after treatment. The results are given in *Table 10.*

TABLE 10. COMPARISON OF RESULTS OF ARTIFICIAL AND NATURAL POLLINATION

Treatment	Number of flowers	Number of inflorescences	Immature fruits after 21 days		Harvested fruits	
			Number	%	Number	%
(a)	347	40	71	20.5	19	5.5
(b)	195	40	0	0	0	0
(c)	193	40	4	2.1	0	0
(d)	1165	40	16	1.4	3	0.26

As usual, a large drop of flowers occurred within 21 days after pollination and in the case of treatment (b) the last flower dropped on the 20th day. It appears, therefore, that any flower which drops within 21 days may not be fertilised and that any flower that remains after 21 days is probably fertilised and therefore may be called an immature fruit. There are therefore two main possible approaches to the problem of improving hand pollination success. The first possibility is to improve hand pollination technique in order to fertilise more flowers, and the second is to apply treatments to the immature fruits growing after 21 days. Observations on the scaffolding suggest that much of the 73% drop of immature fruits in treatment (a) which occurred between 21 days and harvest was the result of damage caused by the caterpillar *Euproctis subnotata* and a Mirid bug *Lygus* sp.

A second experiment was carried out during part of the production of the large family RRIM 501 × 33/520, in which six pollinators were instructed to carry out 3, 6, 9, 12, 15 and more than 15 pollinations per inflorescence on successive

days. The results confirmed previous findings that the fewer flowers which are pollinated per inflorescence the higher is the percentage success in terms of fruits harvested, but that the higher percentage of success may be obtained at the expense of a lower number of fruits harvested per day's work by the pollinators. Nine pollinations per inflorescence appears to be the optimum number under the conditions of this experiment. There was a marked difference between the results of the pollinators. Two of them obtained an overall percentage success which is very significantly higher than that of the other four.

A third experiment, to discover the effect of spraying of solutions of 2,4-D on the drop of immature fruits, was carried out during the flowering season. The treatments in this pilot trial were:

(a) 100 p.p.m. 2,4-D acid in ethanol and water + 0.01% sticker (Tween 20)
(b) 10 p.p.m. 2,4-D acid in ethanol and water + 0.01% sticker (Tween 20)
(c) 1 p.p.m. 2,4-D acid in ethanol and water + 0.01% sticker (Tween 20)
(d) Water + ethanol + 0.01% of sticker (Tween 20)
(e) Control — no treatment.

Ninety inflorescences were treated, eighteen for each of the five treatments.

The 2,4-D treatments did not prevent the fall of immature fruit. There was a tendency for the treatment with 100 p.p.m. of 2,4-D to increase fruit drop when applied at two, three, four and five weeks after pollination.

Drop of Immature Fruits in the Main Programme

The fall of flowers or immature fruits resulting from the hand pollination programme occurred in two main periods; the first three weeks and between three weeks and six weeks after pollination. There was only a small drop between six weeks after pollination and harvest and it occurred in only eight of the twenty families. The rate of drop per day during the first period varied amongst the families from 16.7% to 5.3%, during the second period from 11.8% to 0.4%, and over the two periods combined from 10.2% to 4.9% *(See Table 11)*.

If it is assumed that most of the flowers which dropped during the first three weeks after pollination were not properly fertilised, the least fertile of the selfed families were RRIM 527, RRIM 623, RRIM 628, PB 86 and RRIM 600 and the most fertile selfed families were Tjir 1, RRIM 501, PR 107, LCB 1320 and RRIM 605. The rate of drop of PR 107 selfed between three and six weeks after pollination was the highest and thus accounts for the low final percentage of success. This confirms previous opinions that PR 107 is a poor seeder but that the fall of immature fruit is probably not due to poor fertilisation.

Amongst the outcrosses the rate of drop of the cross PB 5/51 × RRIM 701 in the first period is low (about the same as of Tjir 1 selfed and RRIM 501 selfed) but the very high percentage success (12.8) is the result of a low rate of drop between three and six weeks after pollination. This confirms previous opinions that PB 5/51 is a prolific seeder but that this is probably not due to a higher than normal number of fertilised flowers. The rate of drop in the first period of the cross PB 5/51 × RRIM 600 was similar to that of PB 5/51 × RRIM 701, but the rate of drop between the third and the sixth weeks after pollination was more than twice as high.

TABLE 11. THE DROP OF IMMATURE FRUITS OF THE MAIN PROGRAMME

Family	% success at harvest	Percentage rate of drop per day* 1-3 weeks	3-6 weeks	1-6 weeks
Tjir 1 selfed	7.2	5.3	7.2	6.3
RRIM 501 selfed	6.5	6.3	6.7	6.5
LCB 1320 selfed	4.5	7.8	6.9	7.3
PR 107 selfed	2.0	6.9	11.8	9.3
PB 86 selfed	2.9	12.4	4.5	8.4
RRIM 605 selfed	3.9	8.8	6.2	7.5
RRIM 527 selfed	1.4	16.5	3.8	10.2
RRIM 623 selfed	1.8	16.7	2.4	9.6
RRIM 628 selfed	3.7	14.0	1.5	7.7
RRIM 600 selfed	1.4	12.5	7.5	10.0
PB 5/51 × RRIM 600	5.5	6.7	7.1	6.9
PB 5/51 × RRIM 701	12.8	6.5	3.2	4.9
RRIM 600 × RRIM 701	3.4	12.7	1.5	7.1
RRIM 600 × 51/102	3.2	10.6	4.4	7.5
51/102 × RRIM 701	2.8	15.1	1.9	8.5
RRIM 501 × 33/520	4.7	13.1	0.4	6.7
33/520 × RRIM 501	3.2	15.1	0.7	7.9

*The 'rate of drop' is calculated from the equation

$$Q = \frac{100 (\log e X_1 - \log e X_2)}{t_2 - t_1}$$

Where X_1 and X_2 are the numbers of fruits on the trees at times t_1 and t_2, $(t_1 - t_2)$ is the time interval in days, e is the base of natural logarithms and Q is the required value of the rate. (VYVYAN, M.C. (1946) *J. Pomol.* **22**, 11.)

Selfed Lun N S_1 and RRIM 612 × RRIM 628, which produced no fruits in 1960, again failed.

Hand Pollinated Seedling Trials and Small Scale Clone Trials of Material from Previous Programmes

(a) The heights and diameters of the hand pollinated seedlings produced in 1960 were measured in Field 4 nursery to study the vigour of all the families in March 1961.

The measurements of the five families from the inbreeding experiment which were planted over the same period, and are therefore directly comparable, are given in *Table 12*. It is interesting to note that of all seedlings planted, the family RRIM 605 S_1 selfed has the largest mean diameter in the nursery.

(b) The girths and heights of all the seedlings resulting from the 1959 hand pollination programme and planted in Field 18 were measured and observations were made on their bud, leaf and branching characteristics. Using material from the same programme, a clone trial and two seedling trials laid down in Field 18 in December are described below:

306 clones were made from the most vigorous seedlings in the nursery and planted out as budded stumps. The clone trial is of simple lattice design allowing two plots of six trees for each clone. There are eighteen plots of RRIM 605 as control. The planting distance is 20 × 20 ft.

TABLE 12. MEASUREMENTS IN MARCH 1961
OF FIVE FAMILIES OF SEEDLINGS PRODUCED IN 1960

Families	Type of cross	No. of trees measured	Mean height in inches	Mean diameter in cm (6 in. from the ground)
RRIM 501 selfed	self	114	24.1	0.70
RRIM 501 × RRIM 509	full sib	99	23.2	0.67
RRIM 501 × RRIM 513	half sib	138	23.9	0.69
RRIM 501 × Pil A44	back cross	136	23.9	0.69
RRIM 501 × PR 107	out cross	120	24.1	0.69

In one hand pollinated seedling trial the seedlings which were cloned were planted as 3 ft stumps and were randomised in a single block at a planting distance of 20 × 20 ft. The object of this trial is to compare the performance of the seedlings with those of the clones made from them, under conditions as nearly similar as possible.

The other hand pollinated seedling trial, to evaluate the seedling families, is of randomised block design with fourteen families in five replications. The planting distance is 20 × 20 ft. The seedlings in this trial were chosen at random in the nursery after the selection of the most vigorous seedlings for cloning, and planted as 3 ft stumps.

Table 13 shows the number of seedlings which were in the nursery and the proportions which were cloned or planted out as seedlings.

(c) The hand pollinated seedlings resulting from the 1953 pollination programme, planted in Field 60A, were brought into tapping in April. The tapping system is S/2.d/3.67%.

(d) The small scale trial of clones made from the 1952 hand pollinated seedlings planted in Field 57A was brought into tapping on the S/2.d/2.100% system in July.

(e) Observations and yield recording continued in all post-war seedling and small scale clones trials. No selections for large scale testing were made.

Study of Collections and Introduction of Hevea species

The results of the first year of tapping the small scale trial of clones made from seedlings imported in 1951 are given in *Table 14* (Field 55A). Further imported material was brought into tapping in Fields 55B and 56. Most of the imported clones have now begun to flower and set seed.

Latex collection were made from clones made from the imported seedling collection and from the species crosses *H. brasiliensis* × *H. spruceana* for analysis and examination by the Chemical Division. Yields of some of the species crosses are of the same order as those of their Eastern parents.

Budwood of the most vigorous and the highest yielding clones has been sent to the R.R.I.M. unit in Trinidad for preliminary screening against South American leaf blight.

TABLE 13. SELECTION FROM THE 1959 HAND POLLINATED SEEDLINGS

Family	Number of seedlings (excluding runts)	Mean diameter of seedlings at 6 in., in cm. Nov. 1960	Percentage of runts (not measured)	Number of the most vigorous seedlings chosen for cloning (Percentage of seedlings measured is shown in brackets)	Number of seedlings chosen at random for seedling trial
RRIM 501 × RRIM 623 RRIM 623 × RRIM 501	1524	3.2	12.5	198 (13.0%)	200
RRIM 501 selfed	587	3.1	18.1	54 (9.2%)	200
RRIM 501 × LCB 1320	115	3.1	10.6	5 (4.3%)	100
RRIM 501 × RRIM 628	92	2.9	22.3	5 (5.4%)	80
RRIM 501 × RRIM 614 RRIM 614 × RRIM 501	193	3.1	3.4	6 (3.1%)	100
RRIM 501 × RRIM 632	93	2.8	27.6	5 (5.4%)	80
RRIM 628 × RRIM 632	112	2.8	13.0	5 (4.5%)	100
RRIM 628 × RRIM 614	134	2.9	13.4	6 (4.5%)	100
LCB 1320 × RRIM 632	81	3.0	12.0	5 (6.2%)	70
LCB 1320 × RRIM 628	108	3.1	5.2	5 (4.6%)	100
LCB 1320 × RRIM 614	139	2.8	9.6	6 (4.3%)	100
RRIM 501 × 4 clones of Peruvian *H. brasiliensis*	488	3.4	19.1	6 (1.2%)	100
Total or mean	3666	3.2	14.4	306 (8.3%)	1330

TABLE 14. YIELD IN GRAMS PER TREE PER TAPPING OF CLONES MADE FROM IMPORTED SEEDLINGS

Material	No. of clones	Mean, grams	Highest yielding clone, grams
RRIM 501, 513	2	34.6	
H. benthamiana (Rio Negro origin)	164	5.8	19.4*
H. brasiliensis (Peruvian origin)	159	2.0	6.9
H. brasiliensis (Belem origin)	17	1.8	5.9
H. spruceana (Manaos origin)	1	0.6	

* Probably a hybrid *H. benthamiana* × *H. brasiliensis*.

Methods of Forecasting Yield

Bark samples were taken from the 1959 hand pollinated seedlings which were cloned, for counting of number of rows of latex vessels and estimation of the area of bark occupied by latex vessels for future calculations of correlations with the yield of both the seedlings and the clones.

A miniature trial was planted in Field 2 nursery, to examine as many criteria as possible for selecting clones. Ninety-nine of the seedlings of the family RRIM 501 × RRIM 623 planted in the larger of the two hand pollinated seedling trials in Field 18 were chosen at random and cloned. The clones were planted as budded stumps at a planting distance of 8 × 4 ft in a simple lattice design with two replications of six trees of each clone. Eleven plots of RRIM 501 and eleven plots of RRIM 623 were included as controls.

Thirty-two well known clones were also established in Field 2 nursery to find if characteristics of these young plants are related to known characteristics of the mature trees. Using petiole and green bark tissue collected from the top layer of the canopy of tapped trees of four clones, investigations have been initiated to determine the degree of correlation between the rubber content of such tissues and the recorded yield level of the same trees. The improved bromination method devised by the Soils Division for estimating rubber hydrocarbon has been used successfully and highly reproducible results have been obtained. The percentage rubber content of petiole tissue, but not bark tissue, has been found to vary markedly between clones and in the same direction as the recorded yield. Verification of these results is now proceeding.

Cytology and Breeding Systems of Hevea

Meyer's paradichlorobenzene and Tjio and Levan's 8-hydroxyquinoline have been found to be the most successful fixatives for the cytological examination of the root tips of *Hevea*. After staining with Feulgen's solution, chromosomes can be counted and chromatids, constrictions and trabants can be seen. The root tips of seedlings of *H. benthamiana, H. spruceana* and *H. pauciflora* and of seedlings and rooted cuttings of *H. brasiliensis* have been examined. All

four species were found to have 36 small chromosomes. In general, collections of root tips made between 11 a.m. and 12.30 p.m. resulted in the largest number of mitotic figures.

Meiosis has been studied in several clones of *H. brasiliensis* after smearing pollen mother cells which were fixed in glacial acetic acid and absolute alcohol and stained with iron aceto-carmine. Metaphase and anaphase were found to be normal in the material examined.

The fertility of pollen of different clones is being investigated, using the aceto-carmine glycerol jelly technique. About 70% of the pollen of the clones examined were found to be well filled and stainable. No abnormality was discovered.

During the main flowering season an investigation of the external characteristics of aborting flowers and immature fruits was started. 500 healthy and aborting fruits were examined, their ages ranging from 1 to 13 weeks. The corolla of the female flowers which were successfully pollinated dropped off about 5 to 10 days after pollination, but after presumed unsuccessful pollination the whole flower fell off within 21 days. The immature fruits which aborted more than 21 days after pollination could be distinguished about a week before they dropped by the colour, size and degree of shrinkage of the ovary. Ovaries of healthy and aborting fruits were sectioned and stained with Heidenlain's iron alum haematoxylin. A counter stain of fast green was used. Insufficient data are available for conclusions to be drawn.

Large Scale Trials of Selected Planting Material

Pre-war trials. A limited number of RRIM 500 series clones trials was under recording during 1961; tapping is on a high cut or on two cuts (see under 'Tapping experiments').

Post-war trials. For easy reference the post-war trials have been grouped together as shown in *Table 15.*

TABLE 15. NUMBER OF POST-WAR VARIETY TRIALS

Group	Trials	Mature in Dec. 1961		Immature in Dec. 1961	
		No. of trials	Total acreage	No. of trials	Total acreage
A1	RRIM 600 series (distr. block trials)	19	96		
A2	RRIM 600 series (complete trials)	30	565	3	42
A3	RRIM 500 series and new clones trials	9	120		
B	Foreign exchange clones trials			6	467
C	Clone/tapping and RRIM 700 series trials			9	342
D	Clonal seedling trials			4	109
	Total	58	781	22	960

TABLE 16. MEAN YIELDS IN POUNDS PER ANNUM OF SELECTED CLONES IN EXPERIMENT STATION AND ESTATE TRIALS

(All trials tapped S2.d2.100%)

Experiment No.	No. of tapping year	RRIM 501	RRIM 600	RRIM 605	RRIM 607	RRIM 623	RRIM 628	PB 86	PB 5/51	PB 5/63	PR 107	LCB 1320
RRIES 48A	6	1344	1681	1469	1227							
124	5	1645									1155	
RRIES 48D	5	1390				1683	1970					
123a	4	1039									1237	
132a	4	1208								1360	1207	1137
126b	4	1122		1209				560				1087
123b	3	747		1353				639				
125	3	1163	1071	1059	1028			579	1225		692	
140	3	855		976								
122	3	493	832	498	537							595
143	3	670	738	598						638	438	718
133	3	880	793									
RRIES Hedge Trials	3	771				1176	1208					
134	3	1146				904	1156					
126a	3	1234				1057	1077					
132a	3	532								799	425	699
141	2	1010		1089		1055		534				
135	2	522	670	428								
131	2	860	1147	809	707			606				
136	2	1232	1593									
137	2	1255	1583	1421								

This table includes ten trials at R.R.I.M. Experiment Station (297 acres) and a number of observation areas. Two hundred and forty clones are being tested in these trials.

Group A Trials

Further reports on the RRIM 600 series trials at the Experiment Station were published in *Planters' Bulletin 53,* March 1961, and *58,* January 1962. Clones RRIM 600 and 628 maintain their high yields of about 2400 lb per acre per annum. Further wind damage was experienced in clones RRIM 501, 601, 621 and 627. Weekly observations on seedfall in these trials showed that RRIM 600 and 628 are prolific seeders, while clones RRIM 607 and 612 gave almost no seeds. The boundary trees of clones RRIM 600—618 were stimulated on virgin bark below the cut in October 1961; clones RRIM 600, 605 and 607 showed a good initial response. Clone RRIM 609, which was added to the list of promising clones early in the year, had to be deleted because of rather serious bark deformation.

The yield in lb per acre per annum for eleven clones of interest in the mature group A2 and A3 trials is summarised in *Table 16;* the number of tapping years is given for each experiment in the second column.

The only clone of interest in the distributed block trials (group A1) is RRIM 605; the yield of this clone remains at least equal to that of clone RRIM 501.

Table 17 classifies all tested clones according to the yield per tree in the second and third year of tapping, as a percentage of RRIM 501. Clone GT 1 yielded 81% of RRIM 501 per tree per tapping over the first 9 months of the second year of tapping in the non-RRIM clones trial at the R.R.I.M. Experiment Station.

An 'early tapping' test was carried out in the large scale trial of clones RRIM 630 to 638 at the Experiment Station. The 'yield' of RRIM 632 was promising. Normal tapping in this trial commenced on 1 January, 1962.

TABLE 17. YIELD PER TREE AS % OF RRIM 501
(Second and third year of tapping)

% of RRIM 501	Clones
120–130%	RRIM 628
110–120%	RRIM 527, 600, 613, 614, 626
100–110%	RRIM 605, 616; PB 5/51, 5/63
90–100%	RRIM 603, 621, 623, 624; Ch 26
80–90%	RRIM 526, 601, 606, 607, 609, 610, 618, 620, 625, 627, 629, 630; PB 5/37; LCB 1320
70–80%	RRIM 602, 604, 608, 611, 617, 622; PB T/481, T/495; PR 107
60–70%	RRIM 612, 615; PB 86

Group B Trials

A report on the RRIM Exchange Clones trials was published in December 1961 as *Research Archives of the R.R.I.M. Document 14.* Tapping in the trial at R.R.I.M. Experiment Station is to commence on 1 January 1962.

Group C Trials

In 1961 five RRIM 700 series clones trials were budded on co-operating estates; they contain nine RRIM 700 series clones, three PB 200 series clones and two new Chemara selections, with PB 86 and RRIM 605 as controls. The trials are identical in design. Budding and supplying of all Group C trials was successfully completed at the end of the year. A first report on these trials has been submitted for publication as *Research Archives of the R.R.I.M. Document 16.*

Group D Trials

In the high density experiment to test the Evers Pichel method of selection of seedlings, two rounds of thinning were carried out; the highest stand one year from planting is 908 plants per acre. Thinning of 50% of the plants in the plots with the highest density increased the average height by 13% and lowered the coefficient of variation from 22% to 15%.

Registration of Commercial Fields

A registration of post-war fields planted with clones of interest was set up in order to obtain information on yield and secondary characters in commercial plantings. Post-war plantings of about 280 estates were checked; about 2,000 fields of interest are included in this registration. For each field a card is prepared on which all information that becomes available through visits and correspondence will be entered. Yields will be recorded on corresponding punched cards.

PROPAGATION AND PLANTING METHODS

Crown Budding

Experiments on crown-budding of *Hevea* were initiated because of interest in the South American attempts to reduce the danger of *Dothidella* infection. In general it appeared that natural resistance to the disease (which attacks the leafy crown) was associated with very low yields; it was hoped to overcome this by using high-yielding susceptible clones as trunk components and top budding these with resistant clones. In the first experiment by the R.R.I.M., started in 1950, no *Dothidella* resistant clones were available, but by using clones with a wide range of vigour and yield potential it was hoped to reveal the interaction of crown and trunk.

The clones used were Tjir 1 (vigorous, good yield); LCB 870 (vigorous, poor yield); BD 5 (poor vigour, but good yield capacity in suitable areas), and a clone of *Hevea spruceana* (vigorous, but very low yield). Each of these clones was used as trunk component (in main plots, budded 1951) and also as crown (budded at 6 ft in 1953-54). There were many top-budding failures especially with clone BD 5.

Girth measurements of successful top buddings taken in August 1961 are summarised in *Table 18.*

TABLE 18. CROWN BUDDING EXPERIMENT.
MEAN GIRTH IN INCHES AT 60 IN. FROM THE UNION

Crown	Trunk				
	H. spruceana	LCB 870	BD 5	Tjir 1	Mean
LCB 870	28.7	29.4	28.0	26.8	28.2
Tjir 1	29.4	28.8	27.5	25.8	27.9
H. spruceana	27.8	25.2	23·9	24.6	25.4
BD 5	18.2	19.9	18.2	17.9	18.6
Mean	26.0	25.8	24.4	23.8	

s.e. of the difference between two crown means for any trunk: ± 1.095
s.e. of the difference between two trunk means for any given crown: ± 1.141

Analysis shows that, as in previous years, the crown component has a very highly significant effect on growth, while the effect of the trunk is not established. An analysis of the girth increments 1960-61 similarly does not reveal any effect of trunk on rate of girthing but shows a highly significant effect by crown components.

Yield has been recorded over the first year of tapping August 1960 to July 1961 and results are summarised in *Table 19*.

TABLE 19. CROWN BUDDING EXPERIMENT. MEAN YIELDS FOR FIRST YEAR OF TAPPING IN GRAMS PER TREE PER TAPPING

Crown	Trunk				Crown means
	H. spruceana	LCB 870	BD 5*	Tjir 1	
LCB 870	0.6	2.9	13.9	8.1	6.4
Tjir 1	0.7	4.3	21.0	15.6	10.4
H. spruceana	0.5	1.7	9.4	9.7	5.3
BD 5	—	(1.4)	—	—	
Trunk means	0.6	3.0	14.8	11,1	

* Trees with BD 5 components were tapped for seven months only.

It is seen that the trunk component has a major influence on yield, and that the crown also has an appreciable effect. The tapping cut was opened at 55 in., just below the upper union; it is expected that the effect of the crown will diminish as the tapping cut moves down the trunk, away from the crown.

Very few trees with BD 5 crown have reached tappable size (20 in. girth), and the effect of this component on yield cannot yet be determined. It is obvious, however, that BD 5 as a trunk component has a high yield capacity, and this is enhanced where the crown is both vigorous and of high yield potential as with Tjir 1.

In a second crown budding experiment in Field 60F, popular commercial clones PB 86, Tjir 1 and RRIM 501 have been top budded with nine *Dothidella* resistant clones. The first budding near ground level was carried out in April 1957, the top-budding at 8 ft was started in November 1958 and supplying has now been completed.

Stock/Scion Relationships

The results of seven stock/scion experiments, started before the Second World War, have been published in the *Journal of the Rubber Research Institute of Malaya,* Volume 17. Largely owing to the use of illegitimate clonal seedling families as stocks in these experiments, results have been somewhat inconclusive; there is still need for a definitive experiment to show the relative importance of stock and scion in *Hevea* and this will be started when a satisfactory technique for budding cuttings has been developed.

The only mature stock/scion trial still in recording consists of a comparison of unselected *Hevea brasiliensis* with illegitimate *H. spruceana* seedlings as stocks for four clones, Gl 1, Tjir 1, RRIM 501 and PB 86. This trial was planted in 1948-49, budded in May 1951 and opened for tapping in July 1957. Statistical analysis of the data summarised in *Table 20* indicates that although the scion has a marked effect on yield and growth, the effect of the stock is not established.

TABLE 20. STOCK/SCION EXPERIMENT. MEAN YIELDS AND GIRTHS

(Yields are mean values for the period July 1960 to June 1961 in grams per tree per tapping. Girths are means of the measurements taken June 1961, in cm, at 60 in. height)

Stock		Scion			
		Gl 1	Tjir 1	RRIM 501	PB 86
H. brasiliensis	yield	32.4	35.1	70.4	32.6
	girth	21.2	24.8	23.2	19.7
H. spruceana	yield	26.5	39.5	63.8	34.2
	girth	22.2	24.2	23.5	23.2

Vegetative Propagation of Hevea

Further progress was made in the technique of rooting leafy cuttings of *Hevea* clones and the procedure of hardening-off in order to have good survival on field planting. All rooted cuttings were transplanted from the sawdust and sand rooting medium into polythene bags for hardening-off. The cuttings are ready for field planting when the terminal bud is commencing to flush, at about twelve weeks after removing the cutting from its source.

Cuttings are obtained from cut-back budwood which, by pruning several times, is formed into source-bushes. The green shoots so formed were found to root more readily than shoots of similar appearance taken from the canopy. In addition to the important clones listed previously (PB 86, GT 1 and PR 107), clones PB 5/51, RRIM 600, 623 and 701 were also found to root readily.

A number of trials were made with growth substances including IBA, NAA, 2,4-D and 2,4,5-T over a wide range of concentrations and applied to the bases of the cuttings either in a talc powder or by quick dipping in the solutions. No clear beneficial effects on rooting were recorded. Ferric dimethyldithiocarbamate powder (Fermate) which promotes rooting, is applied as a routine measure to the base of cuttings before their insertion into the mist frames.

The budgrafting of established cuttings has so far proved unreliable. There are indications that the amount of stored food reserves is low in rooted clonal material as compared with young seedlings, and this may be the cause of the failure. The green budding of small rooted cuttings by grafting on the stem between the lowest two leaf-whorls seems promising. Using this method, stock and scion combinations could be prepared in polythene bags in the nursery.

It has been found necessary to stake a proportion of cuttings both on the Experiment Station and in observation plots elsewhere. Large scale field experiments in which cuttings and buddings of the same clones are compared will show if the strong laterals formed on cuttings produce a mechanically stable system; cuttings do not have a tap root.

Comparison Between Cuttings and Budded Stumps

The growth measurements of two experiments planted in Field 64C and 64D are given in *Table 21.* Field 64C planted in November 1959 was set up as a preliminary to the more extensive experiment in 64D which was planted in November 1960. In Field 64C the PB 86 trees from cuttings are considerably larger than from budded stumps but there is a smaller difference in the 64D trial.

TABLE 21. GROWTH MEASUREMENTS, BUDDED TREES AND CUTTINGS

Measurement	FX 652 *H. brasiliensis* × *H. benthamiana*		PB 86		GT 1		RRIM 605	
	Budded stumps	Cuttings	Budded stumps	Cuttings	Budded stumps	Cuttings	Budded stumps	Cuttings
Field 64C Mean height in inches, March 1961			120	154	96	185	116	81
Mean circumference in cm, Dec. 1961			12.0	15.2	11.9	18.4	13.7	11.4
Field 64D Mean height in inches, Dec. 1961	121	109	106	120	109	129		
Mean circumference in cm, Dec. 1961	7.7	6.2	6.1	6.8	6.3	6.8		

Trees of GT 1 from cuttings are rather larger than the buddings in both experiments whereas RRIM 605 and FX 652 buddings appear more vigorous than cuttings.

Budgrafting Small Rootstocks

A nursery experiment in Field 14D was budded at intervals during the year to test the effect of budding stocks from twelve weeks and up to one year old, upon the amount of scion growth so produced. RRIM 501 and GT 1 scions were budded on Tjir 1 illegitimate seedling stocks. The green-budding technique was used for the six stages up to 34 weeks old, and the conventional Forkert method for the budding at 40 and 52 weeks. Initially the rate of growth is slower on the younger stocks but, once the first flush of scion growth is completed, the rate of scion growth on the younger stocks is equal to that on the older ones. Mean heights of scions on stocks, all sown in October 1960, budded at different ages, and measured at the end of December 1961, are given in *Table 22*. The youngest stocks produced a considerable amount of scion by the end of the year.

Success in the green budding treatment in this experiment was low but in more recent experiments success of about 85% seems likely. Budders quickly became proficient and can bud more quickly than by the Forkert method.

TABLE 22. SCION GROWTH ON STOCKS AGED BETWEEN 12 AND 52 WEEKS

Age of stock in weeks at budding		12	16	20	24	28	34	40	50
Date of budding, 1961		3.1	31.1	28.2	28.3	25.4	6.6	18.7	10.10
Mean height of scion in cm, 31 Dec. 1961	RRIM 501	265	240	219	238	108	122	99	20
	GT 1	218	176	180	152	109	63	81	24

The Production of Planting Material in Containers

With the ultimate object of reducing the length of the immature period in the life of rubber trees, the use of the green-budding technique to produce buddings in polythene bags is being investigated in nursery experiments; it is intended to transplant the buddings into the field with some 4 – 5 ft of scion growth in full leaf and with roots intact. Seedlings are being grown in perforated polythene bags of various dimensions containings from 14 – 40 lb of soil. Budding will commence early in 1962 when these stocks are three months old.

Small trials with the same object, but using budded stumps, are in progress. Normal sized budded stumps are planted in polythene bags containing up to 80 lb of soil. The bags are then sunk to their depth in nursery rows and will be planted into the field after the formation of a few feet of scion growth. Arrangements have been completed for a large scale experiment in which such budded stumps will be compared with cuttings planted in containers of the same size.

Planting System

The density-of-planting experiment in Field 53 has been described on page 49 of *Annual Report 1960*. The first round of thinning was carried out in 1956,

TABLE 23. PLANTING DENSITY EXPERIMENT, MEAN GIRTHS IN INCHES AT 60 INCHES HEIGHT

Sub-plot	Planting system	Initial density	West block (Plots I—IV)						East block (Plots V—VIII)					
			Thinned to:		Mean girths:				Thinned to:		Mean girths:			
			in 1956	in 1961	RRIM 513	LCB 1320	RRIM 527	Tjir 1	in 1956	in 1961	RRIM 513	LCB 1320	RRIM 527	Tjir 1
A	30×8	182	145	135	20.9	25.3	22.4	23.9	145	135	21.6	23.9	22.5	22.6
B (i)	50×6	145	125	118	22.5	26.2	22.6	24.4	,,	,,	21.9	24.8	17.8	21.5
B (ii)	50×4½	194	155	144	20.8	24.7	20.8	21.9	,,	,,	22.9	26.3	17.7	19.7
B (iii)	50×3½	249	185	169	21.3	24.1	19.9	22.5	,,	,,	23.2	25.2	20.6	23.8
C (i)	65×4½	149	125	118	23.1	24.8	20.4	22.9	,,	,,	22.0	25.1	21.6	20.4
C (ii)	65×3½	192	155	144	21.7	24.1	20.6	21.9	,,	,,	22.2	25.2	22.2	22.5
C (iii)	65×2¾	244	185	169	20.9	23.9	19.0	20.9	,,	,,	21.8	25.3	20.9	23.2
D	20×12	182	145	135	20.7	24.2	21.7	23.3	,,	,,	21.8	26.9	21.7	22.9
E (i)	80×3½	156	125	118	21.0	24.4	20.7	23.1	,,	,,	22.1	23.1	18.8	19.6
E (ii)	80×2¾	198	155	144	19.3	21.9	19.7	21.1	,,	,,	23.1	24.8	20.9	21.8
E (iii)	80×2¼	242	185	169	20.4	20.7	19.1	20.5	,,	,,	21.0	22.1	20.3	21.5

but as a considerable number of runts still remained (especially in the extreme hedge systems) a further round of thinning was carried out in April 1961. Details of the thinning and mean girth are given in *Table 23*.

It is seen that LCB 1320 is the most vigorous clone, while the RRIM clones are the least. This relationship does not seem to be much affected by planting system. As would be expected the heavier thinning (i.e. removal of the smallest trees) tends to result in a larger mean plot girth. The plots with the highest planting density (B(iii), C(iii) and E(iii)) have consistently higher mean girths within each clone, when thinned to 135 trees per acre as in the East block, than when thinned to 169 trees per acre as in the West block. Similarly, plots B(i), C(i) and E(i) tend to have a higher mean girth when thinned to 118 than to 135 trees per acre.

Treatments A and D were brought into tapping in July 1959, a year before the B and C treatments, while treatment E was not brought into tapping until 1 January 1962. The depressing effect of tapping on rate of girthing has to be borne in mind when considering the girth figures.

Mean yields for all treatments in tapping are given in *Table 24*. The most obvious influence on yield is that of the clone: RRIM 527 is conspicuously the

TABLE 24. PLANTING DENSITY EXPERIMENT.
MEAN YIELDS IN GRAMS PER TREE PER TAPPING

Plot	RRIM 513		LCB 1320		RRIM 527		Tjir 1	
	July–June 1959 1960	July–June 1960 1961	July–June 1959 1960	July–June 1960 1961	July–June 1959 1960	July–June 1960 1961	July–June 1959 1960	July–June 1960 1961
A	26.0	22.0	19.5	19.7	31.3	29.0	12.9	12.8
West Block								
B (i)		28.4		21.5		31.0		18.9
B (ii)		29.7		18.4		30.1		20.1
B (iii)		26.4		17.4		29.7		16.5
C (i)		26.7		19.6		35.0		20.5
C (ii)		26.4		17.9		34.7		21.2
C (iii)		27.8		17.2		36.1		22.4
D	17.1	22.9	18.3	19.5	23.3	26.3	14.5	16.0
A	22.0	26.4	20.8	22.1	30.4	28.4	17.0	14.6
East Block								
B (i)		29.5		23.3		27.0		22.0
B (ii)		32.6		21.9		31.3		19.9
B (iii)		30.6		25.7		29.8		25.2
C (i)		23.1		18.6		33.3		22.2
C (ii)		24.6		20.1		33.9		21.6
C (iii)		22.1		19.2		30.2		25.3
D	19.7	22.9	18.4	21.8	26.5	28.6	13.6	15.2

highest yielding, while Tjir 1 and LCB 1320 are both rather low. No clear-cut effect of planting system on yield can be seen, but trees planted at lower densities were the first to come into tapping; this will be reflected in cumulative yield rather than mean yield.

WIND DAMAGE INVESTIGATIONS

Timber Testing

Timber strength was investigated in five trees from each of six clones in the RRIM 600 series trial in Field 48A at the R.R.I.M. Experiment Station; three of these clones are known to be wind resistant and the other three to be susceptible to trunk snap and wind damage. The heights, girths, and weights of the trees were determined when they were cut out in November/December 1960. Static bending tests were carried out at the Forest Research Institute on specimens cut from two heights, namely: 30 to 60 and 60 to 90 inches above the union.

Comparing the two classes of material it is found that no single criterion of growth or timber property separates them clearly, although the height and girth increments of the wind prone clones have been somewhat less than those of the others over the last five years. A more detailed report on this and similar investigations is being prepared. The data support the view that the moment exerted by the above-ground parts of the tree is relatively greater in proportion to the resistance to movement or breakage (function of trunk size and timber properties) in the prone clones than in the others.

Survey of Wind Damage to RRIM 501

A preliminary survey has been conducted by questionnaire which will be reported in detail later. The first results indicate that trunk snap of RRIM 501 varies in incidence from low to severe without any evident correlation with major soil type or degree of exposure to strong winds. It would appear that susceptibility is largely determined by husbandry practices.

Pruning and Pollarding of Clone RRIM 501

Further observations have been made in the experiments set up in Field 54 to study the effectiveness of various types of pruning in avoiding wind damage and the effects of such pruning on subsequent growth and yield of the trees. In the earlier experiment started in April 1960, two heights of pollarding (12 ft and 30 ft above ground) were compared on a plot basis while the treatments, tapping or not-tapping, were randomised amongst individual trees. No wind damage has yet been experienced in any treatment, nor was it expected, since the area was originally opened for tapping only in July 1959. A summary of the girth and yield records is given in *Table 25*. The untapped trees were brought into tapping in April 1961, one year after the original pruning.

It is rather unfortunate that, owing to a freak of randomisation, the pollarded and control plots started the experiment with the lowest and highest mean girths respectively. However, the subsequent differences in rate of girthing are very marked, and can scarcely be attributed to the initial differences. The untapped control trees increased by 7 cm during the year April 1960—April 1961 while the pruned and pollarded trees put on 1.7 cm and 0.5 cm during the same period.

TABLE 25. GIRTHS AND YIELDS IN POLLARDING EXPERIMENT.
GIRTHS IN CM AT 50 IN. HEIGHT. YIELDS IN GRAMS PER TREE PER TAPPING

Treatments		Girth April 1960	Girth increments		
			Apr.-Oct. 1960 1960	Oct.-Apr. 1960 1961	Apr.-Oct. 1961 1961
Control	Tapped	53.6	2.2	1.0	2.0
	Untapped*	54.1	4.1	2.9	1.1
Pollarded at 12 ft	Tapped	50.1	0.3	0.2	0.5
	Untapped*	50.9	0.3	0.2	0.7
Pruned at 30 ft	Tapped	52.4	0.5	0.4	0.6
	Untapped*	52.8	0.8	0.9	0.6
			Mean yields		
Control	Tapped		26.9	40.9	31.9
	Untapped*		—	—	35.6
Pollarded at 12 ft	Tapped		7.9	13.8	13.9
	Untapped*		—	—	19.1
Pruned at 30 ft	Tapped		15.4	24.5	19.2
	Untapped*		—	—	24.3

* The 'untapped' treatments were brought into tapping in April 1961.

The pollarded trees have continued to yield very poorly, while the pruned trees are also considerably behind the control in this respect. The 'untapped' treatments were, in fact, tapped from April 1961, and it appears that the resting period has improved the yield in comparison with the continuously tapped trees. It remains to be seen whether this improvement will be maintained.

In another experiment in the same field, complete pruning (or pollarding) at 27 ft was compared with partial pruning in which half the main branches were removed in October 1960 while all but one of the remainder were removed in October 1961. Within the main plots (pruning treatments), the treatments, tapping or no tapping, whitewashing, paper-covering or no covering, were randomised amongst individual trees. In this experiment, there has been very little sunscorch on any treatment probably because of the dull cloudy weather which persisted during and for some while after the pruning operations. Hence the effectiveness of whitewash in preventing this form of damage is not proven. However, four months after the start of the experiment, some figures for bark temperatures attained under various treatments were obtained by inserting a needle pyrometer into the bark to a standard depth; these figures give some indication of the protection afforded by whitewash and paper covering (*Table 26*). Although white-

TABLE 26. MEAN TEMPERATURES OF BARK, °C

	Sunny side	Shaded side
No covering	46.2	34.3
Whitewash	36.8	33.0
Paper covering	39.5	32.8

wash appears effective, it is less persistent than paper and needs occasional renewing.

A summary of monthly yield records over the first year is given in *Table 27;* these values are based on three cup coagulations each month. It appears that for a month or two after pruning, trees can more or less equal the control level of yield. Subsequently, the yield declines to 40-60% of the control. The yield of the partially pruned trees is also depressed in comparison with the control, but to a much smaller extent.

TABLE 27. MONTHLY YIELDS IN PROGRESSIVE PRUNING EXPERIMENT (GRAMS PER TREE PER TAPPING)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.
Control	28.4	40.4	39.6	51.4	38.0	39.7	25.7	28.3	33.5	37.3	29.8	36.3
Pruned	30.2	29.5	17.4	14.5	14.4	17.4	12.0	15.8	17.9	19.6	18.1	21.4
Part pruned	23.1	34.5	36.4	41.8	34.4	26.7	21.0	26.2	26.8	30.3	23.8	29.0

The girth figures shown in *Table 28,* indicate that the pruned trees girth at a considerably slower rate than the control trees. The effect of tapping on rate of girthing is appreciable on the control trees, but less on the partially pruned trees and negligible on the pruned trees. It is possible that regeneration of the canopy would be slowed by tapping, but this would not show in girth increment, at least in the early stages. Some trees in the 'tapped' treatment are of less than tappable size, and have not yet been brought into tapping.

Experiments on the effects of postponement of tapping and of alternate daily periodic tapping systems on growth, yield and incidence of wind damage are described under Tapping Experiments.

Prolonging the Viability of Hevea Seeds

Evidence is increasing that storage of seeds at low temperature (40°F) in sealed polythene bags is effective for a limited period only. A severe drop in germination success was experienced in two experiments after fourteen weeks of storage. Storage at room temperature in charcoal or sawdust of 20 – 30% moisture content maintains a high germination success for a considerably longer period.

TABLE 28. GIRTHS AND INCREMENTS IN THE PROGRESSIVE PRUNING EXPERIMENT (IN CM AT 50 IN. HEIGHT)

		Girth Sept. 1960	Girth increments	
			Sept. 1960 — Mar. 1961	Mar. 1961 — Sept. 1961
Control	Tapped	48.1	2.0	1.7
	Untapped	47.9	3.3	2.3
Pruned	Tapped	47.9	0.5	0.4
	Untapped	47.7	0.5	0.5
Part. pruned	Tapped	47.7	1.4	1.4
	Untapped	47.6	2.1	2.1

TAPPING EXPERIMENTS

Prang Besar Further Proof Seedlings

The fifth year of tapping was completed in April 1961. The rate of girthing was similar for alternate daily and third daily tapped trees. The daily periodic tapping systems have been dropped owing to disappointing yields. The experiment is continued but only three tapping systems remain under comparison: S/2.d/2.100%, S/2.d/3.67% and S/2.d/2. $\frac{2\times12m}{24}$.100%. Yield, girth and brown bast data are summarised in *Table 29*.

TABLE 29. RECORDS OF 1961, OF TAPPING EXPERIMENT ON PRANG BESAR FURTHER PROOF SEEDLINGS

Tapping systems	Yield in lb per acre	Dry trees, % of total stand	d.r.c.	Girth increment
S/2. d/2. 100%	1670	7.5%	37.2	1.1
S/2. d/3. 67%	1596	2.8%	38.0	0.9
S/2. d/2. $\frac{2\times12m}{24}$. 100%	1500	2.2%	38.4	1.1

Alternate Daily Periodic Tapping

It is considered that the poor rate of girthing of RRIM 501 when in tapping is one of the main factors contributing to its wind susceptibility.

Following some interesting observations by an estate manager on the enhanced growth rate obtained with a periodic tapping system (S/2.d/2.6m/9.67%) as compared with continuous alternate-daily tapping, a small experiment was set up in the Experiment Station on RRIM 501 of tappable size. The trees were

planted as budded stumps in 1953. Eleven treatments are being compared on a single tree basis with ten replications. (*See Table 30*). The experiment was started on 1 April 1961.

The resting period in both the 67% and 75% systems had a markedly beneficial effect on growth during 1961. Whether this effect will decline as the trees grow older remains to be seen. Further experiments on effects of alternate daily periodic tapping systems have been started on a larger scale on co-operating estates, using clone RRIM 501. Two large scale clone trials have been designed to accommodate two tapping systems one of which will be periodic alternate daily tappings.

TABLE 30. EFFECT OF PERIODIC TAPPING ON RATE OF GROWTH OF RRIM 501
(Girth increment, in cm.)

Treatment	Rested	Mar.—July	July—Nov.
1. S/2. d/2. 8m/12. 67%	April—July	1.8 (Rested)	0.3
2. ,,	Aug.—Nov.	0.1	2.7 (Rested)
3. ,,	Dec.—Mar.	0.2	1.2

		Mar.—June	June—Sept	Sept.—Dec.
4. S/2. d/2. 9m/12. 75%	April—June	1.3 (Rested)	0.3	0.2
5. ,,	July—Sept.	0.1	1.6 (Rested)	0.6
6. ,,	Oct.—Dec.	0.2	0.6	2.9 (Rested)
7. ,,	Jan.—Mar.	0.1	0.5	0.5
8. S/2. d/2. 100%	None	0.2	0.7	0.6
9. S/2. d/2. 100%	None	0.1	0.6	0.6
10. Untapped	Whole year	1.4	1.6	2.4
11. Untapped	Whole year	1.1	1.7	2.0

Postponement of Tapping

In the first trial on a co-operating estate near Malacca where the effects of opening for tapping at four different girth sizes (56, 61, 66, 71 cm) on wind damage susceptibility of clone RRIM 501 are being compared, the 61 cm class was opened in December 1961, a year later than the 56 cm group. The trees in this trial are growing rather slowly, probably because nitrogen has been omitted from the fertiliser applications during the past three years. The area was planted in 1953 at 22 × 10 ft. The mean increment for the year December 1960 to December 1961 was 3.9 cm for the trees in untapped plots, but only 1.6 cm for the tapped trees in the 56 cm girth class. The mean yield for the year was 27.0 g per tree per tapping based on cup coagulations in sample areas.

Girth measurements of sample trees have been taken at intervals of four months (*Table 31*). It will be seen that the November to March period produces the least growth. This interval covers the 'wintering' season.

TABLE 31. GIRTH INCREMENTS IN SIZE-AT-OPENING EXPERIMENT. MEASUREMENTS IN CM AT 50 IN. HEIGHT

	Nov. 1960 — Mar. 1961	Mar. 1961 — July 1961	July 1961 — Nov. 1961
Trees in untapped plots	0.9	1.5	1.5
Tapped trees	0.3	0.5	0.6

In a further experiment on estates in South Johore, the interaction between level of nitrogen application and sizes at time of opening (51, 56 and 61 cm) on clone RRIM 501 are to be studied. Nitrogen is considered the element most likely to affect the size of the canopy and hence influence wind susceptibility. It will be two years or more before the first treatment comes into tapping, but differential nitrogen applications were started in May 1961. A basic dressing of 1 lb Christmas Island rock phosphate and 6 oz muriate of potash per tree is given over the whole area. In a randomised block design, the girth classes are arranged to correspond with tapping task size, while nitrogen levels (0 and $1\frac{1}{2}$ lb ammonium sulphate per tree per year) are applied on a basis of half-tasks.

High or Ladder Tapping

Recording was continued of five RRIM 500 series trials planted before the war. These experiments are now tapped on high panels. The mean yields over the first year of tapping of the 500 series clones trial at the R.R.I.M. Experiment Station are given in *Table 32*. Not all 500 series clones were tested, as the

TABLE 32. YIELD OF 500 SERIES CLONES ON LADDER TAPPING
(July 1960—June 1961)

Experiment I	Actual yield in g/tree/ tapping	Calculated yield in lb/acre/ year	Experiment II	Actual yield in g/tree/ tapping	Calculated yield in lb/acre/ year
RRIM 500—not stim.	74.90	2366	RRIM 513—not stim.	45.35	1729
stim.	99.75	3172	stim.	83.22	2646
RRIM 501—not stim.	93.90	2986	RRIM 519—not stim.	86.25	2743
stim.	126.22	4014	stim.	118.30	3762
RRIM 511—not stim.	108.10	3437	RRIM 520—not stim.	43.75	1548
stim.	120.35	3827	stim.	78.47	2496
RRIM 512—not stim.	63.25	2012	Pil B84—not stim. (control)	44.07	1402
stim.	78.25	2484	stim.	60.80	1933
Pil B84—not stim. (control)	64.55	2053			
stim.	75.52	2401			

experiments remained limited to clones of commercial interest. The experiments were started when all bark of first renewal of the low panels had been tapped out. Clone RRIM 519 with its straight tall stem seems especially suitable for ladder tapping. RRIM 513 is a low branching tree with less bark reserve for high panels. RRIM 501 has yielded extremely well, but the trunk snap problem has to be overcome before this clone can be re-introduced in the planting recommendations. The other clones have serious drawbacks and cannot be considered for the planting recommendations.

Intensive Tapping

The main data of an experiment carried out in Field 33 of the R.R.I.M. Experiment Station have been submitted for publication in the January 1962 issue of the *Planters' Bulletin*. The results show that bark of first renewal should be fully exploited before double-cut tapping systems are introduced. Very good response to stimulation was recorded for the single-cut tapping systems, whereas double-cut tapping systems of 133% and 200% intensity responded unfavourably after a period of high yields lasting $1\frac{1}{2}$—2 years. The first year of tapping of five new estate experiments was not completed by the end of 1961. These experiments compare double-cut third daily tapping systems of 100% and 133% intensity with S2.d/2.100% tapping in renewed bark stimulated at half-yearly intervals.

Relationship between Tapping Intensity, the Use of Yield Stimulants and Fertiliser Treatment

The fourth year of tapping has been completed in the tapping, stimulation and manuring experiment carried out on clone PB 86. Significant effects of manuring on girthing have been established, but not yet on yield. No interaction has yet been established between manuring and tapping systems. A summary of records of the fourth year of tapping is given in *Table 33*. The experiment will be continued, but the S/2.d/3.67% treatment had to be dropped at the request of the estate management. The frequency of stimulant application will be increased to twice yearly from 1962 onwards.

TABLE 33. TAPPING EXPERIMENT ON CLONE PB 86

Tapping systems	Manurial treatments	Yield in lb/acre/yr 1961	Girth, in., Sept. 1961	Mean yield of 4 yrs in lb/acre/year	Total girth increment in inches 1957—1961
S/2. d/2. 100%	No manuring	1238	26.8	1012	5.0
	Manuring	1199	27.5	1014	5.7
S/2. d/2.100% +stimulant	No manuring	1241	26.2	1086	4.8
	Manuring	1272	27.8	1061	5.7
S/2. d/3. 67%	No manuring	960	26.7	817	5.3
	Manuring	976	27.4	839	6.0

In another experiment on clone PB 86 recording was continued under supervision of the research unit of a leading rubber company; three tapping systems are compared at four levels of manuring. High yields have been obtained on 2C/2.d/3.133% tapping but the number of total and partially dry trees is increasing alarmingly. This tapping system has also induced a significant retarding effect on growth, when compared with trees tapped S/2.d/2.100% or S/2.d/3.67%. Some effect of manuring on girthing of trees can be seen on the trees tapped at 100% and 133% intensity but not yet on trees tapped S/2.d/3.67%. No effect of manuring on yield is yet observed.

Study of Dry Trees

An inter-divisional working team has been formed. Experiments are in progress but it is too early to comment on results. The experiment mentioned in the 1960 annual report in which trees of clone RRIM 501 were treated with a bactericide has not yielded conclusive information. Close co-operation is given by the research unit of a leading agency house.

Optimum Size of Tapping Task

The experiment investigating the effect of size of tapping task on yield per tapper, yield per acre and standard of tapping was completed in 1961. The results are summarised in *Table 34*.

TABLE 34. SIZE OF TAPPING TASK EXPERIMENT

Task size	Yield in lb of dry rubber						Time in minutes per tree for	
	per task			per acre				
	No. 1	Lower grade	Total	No. 1	Lower grade	Total	Tapping	Collection
300	12.5	3.0	15.5	942	225	1170	0.372	0.104
350	13.5	3.4	16.9	878	219	1094	0.374	0.107
400	15.9	3.5	19.3	902	197	1095	0.363	0.106
450	17.5	4.0	21.5	884	201	1082	0.354	0.104
500	20.0	4.3	24.2	906	194	1099	0.349	0.107
550	22.1	4.6	26.8	913	190	1105	0.343	0.105
600	22.7	5.2	28.0	858	197	1057	0.331	0.107

The experiment was carried out on Tjir 1 clonal seedlings at an uniform stand per acre of 140 tapped trees, tapped on a half-spiral cut alternate daily. Experimental recording started shortly after the second panel of virgin bark had been opened at 40 in. from the ground.

PHYSIOLOGY AND MORPHOLOGY

Long Term Experiments on Yield Stimulation

The experiment on clonal seedlings, which was started in 1952, was discontinued. The area was replanted in 1961. The results showed a continued satisfactory

response to stimulation at half yearly intervals. A yield increase of 44% was obtained during the six months following the final application of stimulant in November 1960.

A second experiment carried out on buddings of nine clones also continued to respond satisfactorily to half yearly stimulant application. The field is due to be cut out in 1962 when a final report will be prepared. The overall increase in yield up to December 1961 was 40%. Clone AVROS 50 did not respond to the stimulant (1% 2,4,5-T). All other clones reacted favourably.

A frequency of stimulant application experiment, which has been in progress from August 1955 was discontinued in December 1960. Treatments and results are given in *Table 35*. The 1% 2,4,5-T stimulant induced severe damage to the bark, when applied above the cut. This experiment has shown that clonal seedlings (planted in 1930) can be treated with a stimulant at 3-monthly intervals below the tapping cut for a period of 6 years without inducing any sign of exhaustion.

TABLE 35. FREQUENCY OF STIMULANT APPLICATION. MEAN YIELD IN GRAMS PER TREE PER TAPPING

Treatments	Mean yield before experiment started	Mean yield 1955—1961
1% 2,4,5-T applied monthly above the cut	36.1	42.8
„ „ once every two months above the cut	34.6	38.3
„ „ once every three months below the cut	37.4	51.3
„ „ once every six months below the cut	36.2	45.3
„ „ once every twelve months below the cut	37.7	42.6
Control, no treatment with stimulant	36.8	33.4

The Effect of Growth Promoting and Other Substances on Latex Yield

Co-operation continued with Professor G. E. Blackman and the Agricultural Research Council Unit of Experimental Agronomy, University of Oxford. Trials set up to test five compounds supplied by Oxford during 1960 were concluded during the present year. None of the compounds was considered to be sufficiently active to warrant extended trial. Screening of a further six compounds is now in progress. These, together with other compounds tested during the year, bring the total number of substances tested for yield stimulant activity since the commencement of the present programme to well over eighty. The few compounds which show a measure of promise are now undergoing comparative tests with 2,4,5-T and 2,4-D.

A field trial of a number of mixtures containing bactericides and 2,4,5-T, conducted in co-operation with Chemical Division, was discontinued. When tested alone, the bactericides gave only moderate yield increases in this experiment, considerably below the level of the standard 2,4,5-T treatment. Certain

combinations of bactericides and 2,4,5-T were, however, selected for further trial in an experiment on a co-operating estate, but none was more effective than the standard 1% 2,4,5-T yield stimulant.

The Practical Applications of Yield Stimulants

Further observations were made in the experiment set up during the previous year to examine the effect on yield and bark renewal of panel applications of 2,4-D acid and butyl ester in various carriers, to the renewing bark above the tapping cut. The yields for the various formulations varied between 128% and 155% of the untreated control while the thickness of the treated bark ranged from 148% to 248% of that of the control trees. In general, the thicker carriers such as lanolin and palm oil/petrolatum gave slightly higher yield and caused considerably greater increase in bark thickness than did the thinner mixtures such as palm oil, palm oil/coconut oil and Stimulex. The larger increases in bark thickness were accompanied by uneven renewal, swelling, cracking and latex bleeding. Again, there were no consistent differences between the acid and ester formulations.

An anatomical comparison of bark samples from the control, Stimulex and 2,4-D acid in palm oil/petrolatum treatments confirmed earlier observations that the increase in bark thickness resulting from stimulation did not result in an increase in the number of functional latex vessels. Indeed, there was a suggestion of a lower number of latex vessel rings in the trees treated with the palm oil/petrolatum mixture. Extensive malformation of the outer tissues was observed in both the stimulant treatments.

Following on these results, a further experiment was set up in Field 22B, R.R.I.M. Experiment Station, to examine the effect of panel applications of 2,4,5-T butyl ester in a number of hydrocarbon carriers of known viscosities. Preliminary results suggest that all the highest-yielding treatments have induced some measure of bark damage.

These results, together with a growing number of observations, both in our own experiments and on estates, of damage to valuable renewing bark caused by panel applications of yield stimulants, lead us to the conclusion that this method of application cannot be generally recommended where the treated bark is to be tapped again. It is therefore intended to concentrate future work on methods of application to the bark below the tapping cut, unless new yield stimulants are discovered which do not carry the risk of inducing bark damage.

The main disadvantage involved in the application of the conventional stimulant mixtures below the cut is the necessity for scraping the bark before application. It is apparent that, particularly in the case of thick virgin bark, the amount of labour involved will vary greatly according to the depth of scraping. An experiment was started during the previous year to investigate the optimum depth of scraping in virgin bark below high cuts (for details, see *Annual Report 1960*). Full results of this experiment are now available and have been published in an article in *Planters' Bulletin 55*. The yield figures indicate that a very light scraping, removing only the outermost corky layer and revealing a green chlorophyll-containing collenchymatous tissue, gave as good a yield increase as did the deeper scraping methods. If these findings are confirmed, it should be possible to effect a substantial saving in the labour costs of stimulant application in virgin

bark. A confirmatory experiment is now under way. Another experiment is also in progress to extend the observations to renewed bark, although the potential savings are smaller in this case, owing to the comparative thinness of the bark. An experiment using the conventional scraping technique on renewed bark has suggested that three-monthly, rather than six-monthly applications would be advantageous and, since the optimum frequency of application may vary with the depth of scraping, a comparison of different frequencies of application is being made in each of the two new experiments.

Tests on a number of yield stimulant preparations containing penetrating carriers, from a commercial source, showed that they gave yield increases of the same order as 'Ready-Rub'. A number of other mixtures tested during the year for penetrating properties gave disappointing results.

Physiological investigations, described in the *Annual Report 1960,* suggested that the position of the yield stimulant application affected the extension of the latex drainage area and the yield increase obtained. Further experiments have confirmed the observation that applications low down on the trunk on the same side as the cut result in the highest yield increases, presumably because the predominantly upward translocation of the growth regulator ensures its rapid and efficient distribution within the drainage area. Application of the present commercial yield stimulant mixtures to the bark near ground level would, however, carry with it the danger of bark damage. Preliminary experiments have, therefore, been started to see whether damage can be avoided and good yield increases obtained by the application of low concentrations of growth substance to a larger area of bark.

The Physiology of Tapping and Latex Flow

Nearly twenty short-term experiments were carried out during the year in an effort to obtain information on the factors controlling latex flow and the mode of action of auxin yield stimulants. The work may be considered under the following sub-headings:

(a) *Dry rubber content of latex.* It had previously been established that, if the d.r.c. of latex collected is determined at intervals during flow, a sharp initial fall is usually noted, followed by a levelling-out and often a rise, as flow ceases. It was also known that the average rubber content of the latex from trees stimulated with 2,4-D and 2,4,5-T was lower than that from untreated control trees. Further observations have now revealed that this marked and regular fall in d.r.c. during flow, is often not found in yield-stimulated trees. Instead, a series of irregular fluctuations, or even a rise in concentration, during flow is frequently observed.

The fall in rubber content which is normally found is the result of the dilution of the latex within the partially-collapsed latex vessels by the entry of water from the surrounding tissue. In the yield-stimulated tree there is an abnormally low rubber content in the latex vessels near the tapping cut. This, together with the flow of high d.r.c. latex from areas of bark which normally contribute little, means that there is a strong tendency for the d.r.c. to rise during flow, nullifying the effects of the dilution process. It is thought that a rather similar reason may explain the small rise often noted at the end of flow in untreated trees.

(b) *Latex viscosity.* Measurements made with a variable-shear micro-viscometer, specially constructed in Chemical Division, tend to confirm that there is some fall in viscosity of the latex when trees are treated with yield stimulants, but further observations are required before final conclusions can be drawn.

(c) *Dendrometer measurements.* No evidence of a greater contraction of trunk diameter following tapping has been found for yield-stimulated trees, but again, further work is required.

(d) *Freezing point of latex.* Values of – 0.52°C to – 0.73°C have been recorded for latex collected under refrigerated conditions. These figures are within the range reported for *Hevea* latex more than forty years ago. No evidence of a change in osmotic concentration, which might result from yield stimulation, was found. It was noted that, although there was usually some tendency for the osmotic concentration to fall during flow, the effect was much smaller than would be expected from the fall in d.r.c. This is thought to indicate that there is an efficient osmo-regulatory mechanism which minimises the effects of dilution. Again, no clear effects of yield stimulation could be detected.

(e) *Ultracentrifugation studies on latex.* Comparisons were made of the ultracentrifuge separations obtained with latex from yield-stimulated and control trees, employing a fully-refrigerated procedure similar to that employed in Chemical Division studies. Latex was collected for the first 30 minutes after tapping. A greater tendency towards flocculation of the bottom fraction particles was observed in the yield-stimulated samples. Other experiments confirm that that the bottom fraction particles are osmotically sensitive and show evidence of flocculation if latex is diluted with water or mannitol solutions of up to 0.2M. Solutions of mannitol of 0.3M and above do not appear to cause flocculation. In one experiment successive latex samples were collected during flow and centrifuged. The first few samples, taken at the beginning of flow, showed evidence of flocculation of the bottom fraction, the remaining tubes showing no such effect. When a tree was treated with 2,4,5-T, there was an increase in the number of samples showing flocculation, although later samples continued to appear normal. These results easily account for the results of the earlier experiment employing bulked latex samples collected for half-an-hour after tapping. A possible explanation lies in the rapid flow and dilution which the latex undergoes immediately after tapping which could result in osmotic flocculation. In the later stages of flow, the dilution is thought to be a far more gradual process which can be successfully countered by the osmo-regulatory mechanism referred to earlier. When trees are yield-stimulated the initial rapid rate of flow is prolonged for a considerable time, resulting in increased osmotic damage to the bottom fraction particles.

(f) *Latex stability.* An attempt was made to adapt the felt filtration technique, used in Chemical Division for the assessment of the stability of latex concentrate, for use on field latex. After some difficulty, reasonably consistent values were obtained by collecting latex under refrigerated conditions and carrying out the procedure in a cold room at 5°C. In one experiment yield

stimulation with 2,4,5-T resulted in a large increase in yield and a marked fall in stability. A dummy treatment in which the trees were scraped and painted with the yield stimulant carrier without 2,4,5-T resulted in a small yield increase and a corresponding fall in stability. It is thought that these observations result from the flocculation of bottom fraction particles described in the previous paragraph. It is proposed to investigate the possible technological significance of these observations in co-operation with Chemical Division.

The Role of Natural Growth Factors in the Physiology of Hevea

Reports of previous work have indicated the presence of natural growth substances in *Hevea* latex and this has led to an interest in the possible influence which these natural growth substances may have on latex yield and flow. A comprehensive survey of the natural growth substances in latex may provide clues for the better understanding of the physiological processes involved in latex yield and flow. Studies of this kind are therefore of a fundamental nature. No results of immediate practical application are to be expected but fundamental studies such as these provide the best opportunity of elucidating the processes of latex yield and flow, and, possibly, development of methods for early yield forecasting. Work has been initiated with these objectives in mind.

Three bioassay tests for plant growth substances have been established, two employing the coleoptile and the first internode or mescocotyl of Victory oats (*Avena sativa*), respectively, and one employing the coleoptile of wheat.

Previous report had indicated that at times, bioassay work might be hindered by irregular supplies of Victory oats from Sweden. A search has, therefore, been initiated for local materials which may be useful as bioassay materials. Ten varieties of rice have been tested, so far none has proved to be outstanding, but two varieties appear to warrant further tests. This search is being continued.

Experiments on the isolation of natural growth substances from latex of *Hevea* using chromatographic methods and the *Avena* first internode straight growth test have been carried out. Results so far have confirmed previous observations of the absence of indole-3-acetic acid (IAA) in latex extracts. Chromatograms of extracts of latex have shown the presence of growth promoting activity. In latex of clone Tjir 1, growth promoting activity has been obtained consistently on chromatograms of the acid ether-soluble fraction of cold ethanol extracts at Rf 0.6—0.9 using isobutanol-methanol-water (80: 5: 15) as the chromatographic running solvent. Lower activity levels have been obtained at Rf 0.0—0.2 and 0.3—0.5. Consistent growth promoting activity has also been found at Rf 0.4—0.6 using isopropanol-ammonia (sp. gr. 0.88)—water (8: 1: 1) as the chromatographic running solvent; activity of a lower level was occasionally found at Rf 0.1—0.3 and 0.8—1.0.

With the acid ether-soluble fraction of cold methanol extracts, growth-promoting activity was found consistently at Rf 0.8—0.9 and occasionally at Rf 0.2—0.3 and 0.4—0.65 using isopropanol-ammonia (sp. gr. 0.88)—water (8: 1: 1) as the chromatographic solvent. Activity was also obtained at Rf 0.25—0.4 and 0.6—1.0 when using isobutanol-methanol-water (80: 5: 15) as solvent, although these were not very consistent.

Chromatograms of the acid ether-soluble fraction of cold ethyl acetate extracts also gave growth promoting activity at Rf 0.4—0.7 using isobutanol-methanol-water (80: 5: 15) as solvent and at Rf 0—0.4 and 0.6—0.8 with isopropanol-ammonia (sp. gr. 0.88)—water 8: 1: 1) as solvent.

The above results suggest that there is more than one substance present in latex responsible for the growth-promoting activity obtained and that possibly more than one kind of growth regulator is present. Further efforts would be directed towards improving the fractionation and purification of the extracts with the hope of eventual characterisation of the substances.

Chromatographic study of the acid ether-soluble fractions of extracts of latices of different clones has been commenced with a view to investigating the variation of the growth substance content between the different clones and the possible correlation between the growth substance content and yielding capacity of the clones.

Towards the close of the year work has been started on the auxin content of the different fractions of latex separated by ultra-centrifuging; this may show the location in the latex of the substances responsible for growth-promoting activity.

GROWTH STUDIES

Effect of the Relative Size of Stock at the Time of Budding on Growth of the Scion

The principal investigation is based on the growth of trees of two clones, RRIM 501 and RRIM 513 in adjacent blocks, and originally budded on stocks of widely different sizes (measured as girth at 12 in. above ground level). The different stock sizes may in large measure be considered as portraying differences in vigour since all the stocks were of the same age at the time of budding and the different sizes were scattered at random throughout the experimental area. The trees were three years of age in September.

Data collected during the year included monthly girths of all trees and dry weight determinations in January. Results indicate that the positive relationship between tree size and original size of stock at the time of budding, which has been observed in the two previous years, has been maintained.

Table 36 records the average girths as at December and the annual girth increment.

Present indications are that Group III trees might reach tappable size nearly six months before those of Group I.

TABLE 36. VARIATION IN GIRTH OF SCION WITH SIZE OF STOCK AT BUDDING

Stock size at budding	Girth (cm) Dec. 1961		Increase in girth during 1961	
	RRIM 501	RRIM 513	RRIM 501	RRIM 513
Group I 3.0—4.9in.	33.7	32.3	12.6	11.9
Group II 5.0—6.9in.	35.5	34.1	13.0	12.3
Group III 7.0—8.9in.	35.9	35.5	13.1	12.5

From the dry weight determinations in RRIM 513, it was found that trees of Group III were approximately 50% heavier than those of Group I and 11% heavier than those of Group II. In RRIM 501 there was a similar relationship between Groups I and II but trees of Group III were not superior to those of Group II. Root/shoot ratios did not vary significantly between groups and during the 12 months Jan. 1960—Jan. 1961, the relative rates of growth for each stock size and clone appeared similar—about 30g per kg per week. It is in the canopy, the weight of which represents about 50% of the total plant weight, that the bulk of the weight difference between trees of the three stock groups is found.

A second experiment was set up on trees of RRIM 519 to study the effect of the relative size of stock on young buddings during their first few months. Results were in agreement with those published from the above experiment. In addition it was confirmed that the time elapsing before initial bud break increased with increasing size of stock. As a result, the growth of the first flush of leaves was completed more quickly on the smallest stocks. Scion growth however was more rapid on larger stocks, and by the fourth leaf flush such scions were clearly the more advanced.

Growth of Various Planting Materials

(a) Observations to compare the growth performance of two RRIM 501 and 513 have been made on the same trees as are used to study the effect of stock size on scion growth—see above.

Although in terms of girth RRIM 501 is the more vigorous clone, see *Table 36*, RRIM 513 has exhibited a greater total plant dry weight. If this situation is confirmed at the 1962 harvest, after nearly 3½ years' growth, it will be of considerable interest as it would indicate that girth data do not necessarily fully reflect growth vigour. The data show that it is principally through the growth of a heavier canopy that RRIM 513 gains a weight advantage over RRIM 501. Trees of the latter clone often possess heavier trunks, a reflection of the generally higher level at which the canopy was developed.

Estimates of relative growth rates have so far not indicated any clonal differences.

(b) A second experiment was laid out in December 1960 in which the growth of four different planting materials is being compared. Planting materials are rooted cuttings of clone PB 86, budded stumps of PB 86, stumped seedlings derived from the same seed as the stocks for the buddings, and seedlings of clone Tjir 1.

The principal objects of the investigation are, in addition to total growth in dry weight, to report on distribution of growth increment between the various parts of the trees at different stages of growth, root development and root/shoot ratio, and relative growth rate. Comparisons between cuttings and buddings on the one hand, and budded stumps and stumped seedlings on the other should be of especial interest. Heights were measured weekly until the plants reached about 12 feet after which girth measurements (monthly) were substituted. Total dry weight estimates on twelve trees of each planting material have been undertaken quarterly.

Throughout the period, cuttings have shown superior performance and in all measurements have shown the least variation. At planting out (145 plants of each material), there was 100% establishment of the cuttings compared with 22 failures of buddings (15%), 5 failures of stumped seedlings and 10 seedling

failures. Immediate supplies to replace failures were made. The average increment in height at the end of the first 44 weeks is shown for each material in *Table 37*. The cuttings were markedly superior to the other materials and the stumped seedlings have grown better than the budded stumps. The first girth data available show in fact the four materials to be in the same order by girth as by heights, but it is as yet too early to estimate accurately the variation between them as many trees are still too small for measurement.

TABLE 37. HEIGHT INCREMENTS OF VARIOUS TYPES OF PLANTING MATERIAL

Planting material	Height increment during first 44 weeks
Cuttings	113 inches
Budded stumps	75 „
Stumped seedlings	89 „
Seedlings	61 „

Examination of the total dry weight data after the first year of growth shows that the cuttings are the heaviest plants, closely followed by stumped seedlings, then budded stumps and seedlings while the average increment for the first year follows the same order. Calculation of relative growth rates shows however, that seedlings and cuttings have maintained a distinctly higher rate of growth through each of the four quarters of the year than the stumped seedlings and budded stumps — no doubt in part a reflection of the method of establishment in the field of the latter materials. Differences have narrowed however with each succeeding quarter. Considering the relative growth rate of the root and shoot separately, it is found that it is in root growth that the transplanted stumps seem to have been particularly retarded even up to the fourth quarter.

In distribution of dry weight increment between root and shoot during each quarter, it is significant that root increment forms a much lower fraction of total increment in cuttings than the other three materials. The nature of the root system of cuttings is distinctly different from the others — numerous adventitious roots radiate from the base of the tree and even after only nine months growth they were 10 feet or more in length, whereas with the other materials, laterals were found not to exceed about 3 feet in length. The tap root of these latter trees penetrated from 4 to 6 feet (except in the case of small seedling trees); the roots of cuttings did not exceed a depth of about $2\frac{1}{2}$ feet. Thus the relatively small, yet extensive and radiating root system of cuttings maintains a plant with a very vigorously growing shoot system. The total growth advantage resulting from the low root/shoot ratio is expected to become clearer during the second year of growth.

Effect of Tapping on Growth

An experiment to study the effect of tapping on the differential in dry weight increment between trunk and canopy is being carried out on a co-operating estate.

Six clones are included in the investigation, RRIM 604, 605, 612, 618, 621 and 501; each clone is replicated four times by plots and within each plot a row of 15 tapped trees and a row of 15 trees remaining untapped have been demarcated. Tapping commenced in May 1961. Felling for dry weight determinations will be undertaken in about two years time.

Anatomical Investigations

(a) *The effect of 2,4-D on the anatomy of the bark.* It was shown that renewing bark treated with a 2,4-D containing yield stimulant produced heavy proliferation of periderm tissue, often resulting in malformations. The number of latex vessel rings was not increased; there was a decrease in number of new latex vessel rings produced by the cambium after application of a yield stimulant.

(b) *Dry trees.* A large number of bark samples, collected periodically from trees subjected to intensive tapping, were examined in an attempt to recognise early anatomical symptoms of dryness. No consistent results are available.

(c) *Early yield prediction.* Work is in progress to establish a method which would enable a quantitative determination of latex-producing tissue in the bark of *Hevea brasiliensis*. The method will be reported later. Preliminary results on trees of known clones and known yield capacity were encouraging.

(d) *Vegetative propagation.* Preliminary studies on a few one-year-old cuttings and seedlings indicated that the seedlings had a higher starch reserve. This may account for the ability of the seedlings to withstand hard pruning after budding.

Cuttings planted out for rooting in the mist propagation unit were sampled periodically to investigate the influence of starch reserves and/or other anatomical features on the rooting ability of different clones. Six clones and seedlings were included in this study. Sections are being studied but final results are as yet not available.

ECOLOGY

Identification and Classification of Plants Found Growing in Association with Hevea

Specimens of nearly fifty plant species were added to the herbarium. Seed of over fifty leguminous species and varieties were obtained by exchange with Australia and India or by selection from the local flora. These will be added to the living collections. Work has begun on a key to leguminous seeds and illustrations of common plants to aid identification.

Effect of Cover Plants on the Performance of Hevea

The girth measurements at the end of each of the first three years after completion of budding (with RRIM 603) in Field 23 have been analysed. Nine cover treatments are compared in a special duplicated square lattice design of four replications. The range from the worst treatment mean to the best was 17% of the overall trial mean one year after budding and 22% in the second and third

years. The degree of significance between treatment effects has fallen from $P < 0.001$ to $P < 0.05$ over the three years perhaps owing to poaching effects. The cover treatments which consistently rank highest over the three years are, in descending order of effect on girth:

(1) Creeping Legumes (conventional mixture of *Calopogonium mucunoides*, *Centrosema pubescens* and *Pueraria phaseoloides)*
(2) *Panicum nodosum* (syn: *Ottochloa arnottie, Hemigynnia fusca)*
(3) *Flemingia congesta* (typical form)
(4) *Axonopus compressus* and *Paspalum conjugatum*

The following five cover treatments resulted in girths less than the overall trial mean; the first three of these have varied in ranking between themselves but have always occupied positions 5 to 7 between them, given in the order at three years after budding:

(5) *Melastoma malabathricum*
(6) *Brachiaria mutica*
(7) *Ficus* species mixed (mainly *F. alba* and *F. fistulosa*)

The following two species have always had the worst effects; their ranking has been reversed in the last year:

(8) *Eupatorium odoratum*
(9) *Mikania scandens*

In general the growth of the trees is proportional to the nitrogen content of the leaves of the cover plant.

The trial in Field 24 has failed to show any marked effects to date.

The trial in Field 17 compares twelve cover treatments factorially with two methods of replanting (mechanical versus felling with stump poisoning). The methods of replanting have shown no clear effects, except on root disease incidence which in the mechanically clean cleared replications is about half that in the felled and stump poisoned plots. Cover type effects on root disease incidence are not significant.

Cover plant effects on height were detected one year after budding RRIM 519 and on girth six months later. In general growth of the trees is better in the leguminous treatments than with non-leguminous covers, except that *Flemingia congesta* is disappointing in this trial and *Panicum trigonum* (a light grass) is close to the best legumes in its effect. Despite the ill effects of *Stylosanthes guyanenesis* (subsp. *gracilis*) reported by others, it has ranked first or second—according to mode of assessment—in its effects on *Hevea* in this trial. The other outstanding observation in this trial is the deleterious effect of *Cordia cylindristachya* on the growth of *Hevea*, so much so that this Boraginaceous shrub has now been eradicated from the trial as a noxious weed risk in view of its rapid dispersal by birds.

The pilot experiments in Field 6 on mowing grass and heavy phosphate applications to legumes have not yet shown significant effects.

In the area destined for comparison of management methods in Field 20, seeding height at the time of budding was significantly greater with a legume cover than with a cover of regenerated weeds.

Vegetation sampling was continued in cover plant trials on four sites using the same technique as previously. Two sites showed an increase in the number

of species suggesting good regeneration. By the end of the third year, it was found that coverage was considerably reduced owing to the deliberate removal of the more woody species, *Trema orientalis* and *Mallotus cochinchinensis.* A herbaceous weed *Stachytarpheta indica* of the family Verbenaceae and composites such as *Blumea balsamifera, Erechthites valerianifolia* were the dominant successors. The most frequent ferns were *Stenochlaena palustris* and *Nephrolepis biserrata;* the latter was most predominant on slopes. It is intended to study these changes in more detail by the use of permanent quadrats.

Root systems of six cover plants were excavated by washing, to study root spread and root system morphology. Recording of sampling at 3 and 6 months after planting was completed. Vertical and horizontal spread, number of main laterals, weight of root and shoot and weight of nodules were recorded. The first sampling showed that the covers had similar rankings for weight of root and shoot systems in the decreasing order *Mikania scandens, Stylosanthes guyanensis* (subsp. *gracilis*), *Pueraria phaseoloides, Centrosema pubescens* and *Flemingia congesta. F. congesta,* which is known to be a slow starter, came first in the second sampling followed by *Stylosanthes, Mikania, Pueraria* and *Centrosema.* The roots of *Axonopus compressus* were more concentrated in the 0-3 in. and 3-9 in. levels (below which they were sparse) than those of other cover plants.

Production and Storage of Leguminous Seeds

Ad hoc investigations have shown that the proportion of hard seed in legumes is smaller if the seed are harvested: (a) slightly under-ripe rather than over-ripe; (b) in dry seasons rather than wet; (c) dried rapidly by sun (or infra-red lamps) rather than slowly in a room.

Establishment and Diversification of Legume Cover Plants

The 'Legume Adaptability Trials' of forty species on ten sites were inspected twice and the more interesting results were as follows:

Calopogonium caeruleum. This creeper, which has a dark green leaf even on poor soils, appears to be a valuable addition to the range of covers if seed production can be improved. The spread is rapid although the stand is not dense at first.

Cassia mimosoides is a promising small shrub, the roots usually being very well nodulated.

Clitoria rubiginosa, useful, especially in mixtures, but subject to die-back in places. Therefore, like most species *C. rubiginosa* cannot be recommended as a sole cover. Seed production fairly good.

Crotalaria species: of the well known *C. anagyroides, C. striata* and *C. usaramoensis,* only the first survives pest and disease attack sufficiently to be of value. *C. anagyroides* is a vigorous tall growing shrub, which does not stand slashing well if not brought under control early. Its main value is as a nurse for more slowly established shrubs such as *Flemingia* and to provide large quantities of mulch material. *C. globosa* is a promising small shrub.

Flemingia congesta. The typical form retains its position as a slow starting shrub, which later produces adequate mulch, stands slashing well and is fairly shade tolerant. The variety *semialata* has been distributed by the trade and the variety *latifolia* is receiving attention.

Leucaena glauca does not establish rapidly enough on the usual acid soils of Malaya for general use.
Mimosa invisa var. *inermis* does not seem to be of much value, owing to the difficulties of keeping seed stocks free from introgression by thorny plants.
Phaseolus angularis has considerable value as an edging plant along the borders of rows; it does not grow so tall as to shade the young rubber, but restrains the growth of creepers into the rows where they are troublesome.
Phaseolus calcaratus is ephemeral in performance, often dying back during seeding, but a useful cover in a mixture.
Psophocarpus palustris has been very slow to establish under Malayan conditions; seed production is poor and it shows little promise.
Pueraria phaseoloides retains its position.
Stylosanthes guyanensis subsp. *gracilis* rapidly establishes a dense, almost weed- and pest-free cover. If the contradictory evidence on its effect on *Hevea* growth can be resolved by finding methods of preventing it from becoming competitive, this plant would be assured of a prominent place in cover crop usage.
Tephrosia candida, T. noctiflora and *T. vogellii* are useful shrubs intermediate in characteristics between *Crotalaria anagyroides* and *Flemingia* varieties.
Vigna triloba and *V. vexillata* after initial promise and rapid early coverage have succumbed to pest attack on most sites.

The trial of various species in North West Malaya, especially North Kedah, supports the view that seed set is better in that region than in most of Malaya.

CONDENSED REPORT FOR THE YEAR 1961 OF THE DOTHIDELLA RESEARCH UNIT OF THE RUBBER RESEARCH INSTITUTE OF MALAYA AT THE UNIVERSITY COLLEGE OF THE WEST INDIES (FACULTY OF AGRICULTURE), IMPERIAL COLLEGE OF TROPICAL AGRICULTURE TRINIDAD, W.I.

The purpose of the unit, established during the latter part of 1960, is to study *Dothidella ulei*, the causal organism of South American leaf blight of *Hevea*. During 1961, the first full year of the unit's activity, the primary objective has been to establish reference collections of both the host *(Hevea)* and the parasite *(Dothidella)*.

Hevea Imports

Hevea material has been despatched as budwood and budded stumps from Malaya to Trinidad by air. The success achieved has improved with successive shipments, largely as a result of better appreciation of our needs by the airways. By the end of the year thirty-eight clones of *Hevea* had been established in nurseries. The collection includes representatives of the following classes of *Hevea* material:

(a) *Hevea brasiliensis* selected in South East Asia and expected to prove very susceptible to South American leaf blight (i.e. typical 'oriental' clones derived from the Wickham collection).
(b) *H. benthamiana* and *H. brasiliensis* primary clones selected for resistance to South American leaf blight in Brazil.
(c) Progeny of crosses of the above two classes of material.

(d) *H. benthamiana, H. brasiliensis, H. guianensis, H. pauciflora* and *H. spruceana* clones (established in Malaya subsequent to the Wickham introductions) whose degree of susceptibility to South American leaf blight is unknown.

It is anticipated that differential responses to inoculation by various *Dothidella* strains will be obtained and screening of the last group of material may provide the R.R.I.M. with new primary resistant selections for further breeding work, because the clones have been chosen to include those which have favourable yield, growth or form characteristics. Nurseries are located within the College grounds, at the College New Farm and at the El Reposo test site (described below).

El Reposo Test Site at the Government Agricultural Demonstration Station Near Sangre Grande

Some of the above mentioned material has already been established at this test site together with seedlings of local origin. The latter may be divided into two categories, seed from trees of unknown history at the El Reposo Station which have shown resistance and seed from commercially exploited trees, possibly derived from the Wickham collection, which have proved very susceptible unless protected by regular spraying of a fungicide. These observations indicate that adequate supplies of at least partially resistant and of highly susceptible seedlings are available locally, moreover the test site is satisfactorily located for screening under conditions of natural severe leaf blight attack.

Culture of Dothidella ulei

So far it has not been possible to establish cultures from single isolated macroconidia although a range of natural and synthetic media has been tried. It has been necessary to use clumps of germinated spores if continued growth after germination is to be maintained. The following observations have been made using such material.

Dothidella ulei is a slow growing fungus producing only limited numbers of spores in culture. A range of agar media has been employed. The best mean growth so far, 9.0 mm per month at 23°C, has been obtained with an agar medium containing 2.5 g per litre of malt extract. The highest mean number of macroconidia, estimated at 93,000 spores per colony at 23°C, has been obtained with commercial (Difco) lima bean agar. Microconidia have been observed only on a potato dextrose agar prepared in the laboratory. No ascospores have been observed on any medium. The following mean temperatures have been tried: 23°C, 25°C and 28°C, and both growth and macroconidia production decline with increasing temperature.

In order to maintain a reference collection of different strains of the fungus it is necessary to be able to make seral sub-cultures. Mass hyphal transfers of cultures raised from macroconidia on infected leaves have been made on lima bean agar at 23°C over three generations of eleven weeks each. A decline in sporulation, and later in growth rate also, was observed. Therefore this method appears to be of limited value to maintain seral cultures especially if spores are required for leaf inoculation. Work is in progress using various approaches to resolve the above difficulties.

The cytology of *Dothidella* may provide a key to its behaviour in seral culture. Preliminary studies suggest that the conidiophore and each cell of the pair normally constituting a macroconidium are all uninucleate; the chromosome number is probably eight.

Viability of Spores

Apart from the influence of this factor on the etiology of leaf blight, it may prove of considerable importance in devising better phyto-sanitary protection for the areas into which *Dothidella* has not yet been introduced. Macroconidia exposed to normal diurnal rhythms of daylight and darkness have a better viability than spores stored in the dark; viability is improved by storage at 23°C compared with 28°C. The percentage germination of spores in distilled water after storage at 23°C in daylight progressively falls from nearly 60% to zero in two weeks.

Alternative Screening Methods

The test site at El Reposo for field screening of *Hevea* material for degree of susceptibility to *Dothidella* has been described above. However, for refined studies of the action of fungal strains on different host clones, a method allowing better control is desired. Experiments with detached *Hevea* leaves have shown considerable promise but a surface sterilising method has to be perfected to prevent complications through field contamination.

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P. DE JONGE
Acting Head of Botanical Division

Pathological Division

Over the past few years, as the other diseases of rubber have been investigated and written up in *Planters' Bulletin,* attention has increasingly been directed to solving the root disease problem; first in relation to replanting, later to new planting from jungle. Several approaches have been followed. Because new centres of infection arise through the colonisation by wind-borne spores of stumps left after felling, chemical treatments designed to protect stumps of felled trees from spore colonisation by root parasites are being tried on a field scale. Factors that might influence spore dissemination, germination and colonisation of wood — including the possible role of insects — are being studied, as are competitive wood-destroying saprophytes. Because the hazard of root disease spread in areas cleared by poisoning is reduced by rapidly killing the trees or stumps, permitting the access of saprophytic fungi, the effects of various poisoning procedures and of delayed felling after poisoning have been studied. The procedures employed in treating diseased trees have been broken down into their component parts and used singly or in suitable combinations to find the essential minimum treatment needed to save an infected tree; the findings are now being tested in large-scale field experiments under estate conditions.

The trend over the past few years has been towards simplifying control procedures, effecting considerable economies by allowing infected material to be disposed of by organisms of decay instead of by hand eradication and burning. For *Fomes lignosus,* the most rapidly spreading of the three major root diseases, it is now clear that a policy based largely on biological eradication can be advantageously employed, concentrating control measures on protecting the young tree rows for the few years that it takes for old timber — the reservoir of root disease — to decay. The position with regard to *Ganoderma pseudo-ferreum* and *Fomes noxius* is less clear and is accordingly now receiving more attention.

It is anticipated that it will soon be possible to bring to a close most of our replanting experiments, which have already given much of the information required from them, and to put more effort into the problems of new plantings, which have recently become of greatly increased importance. Experimentation in jungle clearings, testing procedures which have been successfully employed in replantings, is at too early a stage to support any departures from earlier recommendations to trace and eradicate sources of infection.

A considerable amount of routine phytosanitary work has to be done in connection with the movement of planting material, and to maintain facilities for an eradicant campaign against South American leaf blight should it be conveyed to this country. In addition, attention has recently been given to pathological conditions of the stem, which may have a bearing on the problem of trees that go dry or are susceptible to wind damage.

The steady replacement of unselected seedling trees by clonal planting material is raising some new problems but is more particularly bringing known pathological conditions into greater prominence. One of these is *Gloeosporium* leaf disease. In future more attention will need to be given to investigating clonal susceptibility to disease, and perhaps also to pest attack.

RESEARCH

ROOT DISEASES

Treatment of Infected Young Trees

Two similar experiments laid down in 1960, designated B-60 and SY-60, are concerned with the treatment of naturally infected Tjir 1 clonal seedlings. B-60 was sited in a field of 4½-year-old trees growing mostly on alluvial clay in an area liable to water-logging; SY-60 in an area of 6-year-old trees growing on a well drained lateritic soil. In both places *F. lignosus* had caused heavy losses. The extent of growth and penetration of the fungus was recorded for each tree prior to its receiving one of ten treatments, which were in two series. In the first series, one treatment was the complete 'classical' treatment — excision of penetrated wood, removal of surface rhizomorphs, surface application of a tar acid fungicide, finally tarring all wounds made in exposing the roots or in excising infected tissue. For comparison there were three treatments, omitting the fungicidal application, the removal of rhizomorphs, or both operations. In the second series there was no removal of surface rhizomorphs; penetrated laterals were pruned off but no other excision of penetrated wood was done; all wounds were tarred. For comparison there were five other treatments involving the application of various fungicidal dressings to the penetrated wood.

Every tree was opened for inspection at 6, 12 and 18 months in B-60; at 6 and 12 months in SY-60. All trees in the first series recovered from the original infection, including some that initially had part of the collar or tap root penetrated, showing that the essential operation is to cut the tree off from the source of infection; epiphytic mycelial and rhizomorph growth is harmless, requiring neither removal nor fungicidal treatment provided it has no food base to support it.

Of the trees in the second series, a high proportion of those that had less than half the circumference penetrated showed signs of recovery after a year (78 out of 83 in SY-60 and 111 out of 187 in B-60) and even some of those initially penetrated over more than half the circumference (42 out of 96 in SY-60 and 33 out of 264 in B-60). The position in B-60 was not materially changed after a further 6 months. The fungicidal dressings used gave no beneficial effects. The extent to which trees can heal over infected tissue once the source of infection has gone is remarkable, but it cannot be assumed that recovery will be complete in all cases.

Protective Fungicidal Dressings

The current method of controlling root disease in young rubber entails repeatedly opening the collars of trees neighbouring those found diseased, during quarterly rounds of inspection and treatment. Though the procedure ensures early detection of root disease on these trees and their protection by timely treatment, it is evident that a chemical dressing which gave a lasting protection to the collar would be a further safeguard against root disease losses occurring in groups; it might also be possible to leave a longer interval between inspections. The problem is to find a chemical which is not only active but also stable in soil,

and one that can be formulated to give a continuous layer over the roots, resistant to leaching. The results of a small scale field test with certain experimental or proprietary materials have been so promising that more extensive trials have been put down with an extended range of formulations. Each has been applied to ten trees in each of two fields, half inoculated with *F. lignosus* and half with *G. pseudoferreum*, using naturally infected root sections in the usual way. The first observations will be made early in 1962.

Decay of Rubber Stumps

In Field 14E on the Experiment Station, the decay of rubber stumps is being studied in relation to: (i) tree or stump poisoning; (ii) sodium arsenite or 2,4,5-T as the poison; (iii) creeping legume covers or none; (iv) the presence or absence of root disease fungi, and (v) insecticidal applications to the stumps and soil to discourage borer and termite attack, or no insecticidal treatment. The five pairs of treatments have been combined factorially. In Field 14E2, replanted in 1960, the eight treatments derived from (i), (iii) and (v) are randomised on plots in four blocks, while the four treatments derived from the (ii) and (iv) are randomised on sub-plots. A scheme for sampling stumps for excavation to record the extent of their decay after 18, 24, 30 and 36 months has been prepared. Though a study of the spread of root disease on to the young rubber was not planned as part of the experiment, it is interesting to record that, where the inoculated stumps are concentrated in plots where there is no cover, almost all the nearby young plants have been killed within a year.

Field 14E1, replanted in 1961, has been laid out to measure the effects of the experimental treatments on the young stand. Sodium arsenite was omitted, partly because of a prospective ban on its use, partly because of the apparent superiority of 2,4,5-T. Tree poisoning was also omitted from the treatments, as was the application of insecticides, but *G. pseudoferreum* was included among the inoculation treatments. *F. noxius*, being the least important of the three major root diseases, was not included but a few stumps on the edge of the experimental area were inoculated for observational purposes. The six treatments (stumps inoculated with *F. lignosus*, *G. pseudoferreum* or not inoculated—combined with creeping legume covers or no covers) are randomised on 1/6 acre plots in eight blocks. The area has been planted with basket seedlings for later budding.

Size of Infective Sources

Relevant to the investigation of the decay of rubber wood, where the interest is in how soon sources of infection cease to be infective, is an enquiry into the minimum size that a piece of infected wood must be in order to induce a self-perpetuating infection. There are grounds for expecting a relationship between the size of a tree and the size of an inoculum that can cause its death. To find what the relationship is for *F. lignosus* and *G. pseudoferreum*, trees in Fields 17, 60G, 48B and 35 on the Experiment Station, of ages approximating to 3, 6, 13 and 26 years, have been inoculated with sections of naturally infected root approximately standardised by selecting those which are penetrated yet still hard. The inocula were of volume approximating to 5, 15, 45 or 135 cu. in.

Pre-planting Eradication of Root Disease

Two experiments (SR-57 and J-57) were laid down in 1957 on co-operating estates with the primary object of investigating the value of eradicating root disease prior to replanting. Centres of infection in the new stand have been detected in both areas by quarterly rounds of foliage inspection, at the same time inspecting the collars of neighbouring trees. More recently the need for repeated inspections of these trees has been recognised, and they are now marked for inspection at successive quarterly rounds. Sources of infection have been traced no further than the edges of the weeded planting rows.

Losses from root disease in SR-57 (due almost entirely to *F. lignosus*) having fallen to a very low level after four years of routine treatment, a 'precautionary' inspection of the collars of all the trees was carried out during the tenth and eleventh rounds in June and September. No new cases having since come to light, it would appear that the existing records will represent fairly closely the final outcome of this experiment. Details of the six treatments are given below:

No eradication of old diseased trees: (1) trees felled and the stumps poisoned, the timber stacked; (2) trees felled and the stumps poisoned, the timber removed; (3) standing trees poisoned.

Partial eradication of old diseased trees: diseased trees winched out, diseased roots dug out and burnt, dead stumps isolated: (4) healthy trees felled and the stumps poisoned, the timber removed.

Complete eradication of old diseased trees: all diseased and dead trees winched or dug out, diseased roots burnt: (5) healthy trees felled and the stumps poisoned, the timber removed; (6) healthy trees poisoned standing.

The results quoted below are mean losses due to root disease per acre for five replications on one-acre plots.

Treatment number	1	2	3	4	5	6
Trees removed per acre	9.2	8.2	7.6	7.6	6.8	6.4

Lower losses following pre-planting eradication were to be expected, but the smallness of the differences is a surprise, particularly in view of the post-planting control procedure, which left the bulk of the sources of infection in place. The implication of the results is that it is not economic to attempt the preplanting eradication of *F. lignosus*, provided that a high standard of upkeep is to be maintained in the replanting and that the essentials of root disease control are to be scrupulously carried out.

No answer can yet be obtained from Experiment J-57, where the old stand was heavily infected with *G. pseudoferreum*. Losses in the young stand there have not risen above an insignificant level, red root disease being so much slower in its spread.

Methods of Clearing Old Rubber

In experiment CI-51, where various pre- and post-planting procedures were compared for their effect on root disease incidence in a replanting on a coastal alluvial soil, a striking result was the superiority of tree poisoning over felling and stump poisoning. Possible reasons for the disparity were seen in the spore colonisation of the cut surfaces of the stumps and of the felled trunks, which were left on the ground, and in the vegetative spread of the fungus on the

surface timber. These factors do not, however, appear to have had much adverse effect in experiment SR-57. Tree poisoning has, moreover, a serious disadvantage in the damage done when the tree breaks up. The situation is worse with 2,4,5-T than with sodium arsenite poisoning because the trunk breaks before the crown has disintegrated.

Experiments have therefore been carried out to observe the effect of felling trees at intervals after poisoning, in the hope that the advantages of tree poisoning can be combined with the convenience of felling. The first such experiment was CI-56, located near CI-51, where *F. lignosus* was the dominant parasite. Trees poisoned with either sodium arsenite or 2,4,5-T were felled 0, 1 or 2 months later, giving six treatments which were replicated four times on randomised 2-acre plots. The plots were later sub-divided twice, to superimpose two pairs of post-planting experimental treatments. In the table of the results to date, which are believed to be near the final figures, the sub-plots where the stumps received a surface dressing (+sd) are shown separately from those that did not (–sd). The counts are not broken down to show the other post-planting treatments, but the indications are that losses would have been about 10% lower had the whole area received the better treatment.

TABLE 38. MEAN CUMULATIVE LOSSES OF TREES FROM ROOT DISEASE PER ACRE. EXPERIMENT CI-56

Poison		Period between poisoning and felling (months)		
		0	1	2
2,4,5-T	+sd	9.00	7.00	6.75
	– sd	9.75	9.75	12.25
Sodium arsenite	+sd	10.00	6.50	4.25
	– sd	11.25	7.25	7.75

+sd = with
– sd = without
} a surface dressing applied to the old stumps.

Experiment S–60 represents another approach to the same problem. Here trees poisoned with 2,4,5–T by the standard method — painting the basal 15 inches of the trunk with a 5% solution in diesel fuel oil — were felled at weekly intervals from 0 (equivalent to stump poisoning) to 9 weeks after poisoning. The cut surfaces of the stumps were immediately treated with creosote. Sample groups of five stumps have been excavated after 6, 12, 15 and 18 months to expose the top of the tap root and the bases of the laterals, to record any part remaining alive. The second inspection showed death to be so advanced that the two subsequent inspections were made at closer intervals.

At six months the results for successive weekly periods between poisoning to felling showed large fluctuations; thus, out of five stumps sampled, the numbers with some living roots at the successive sampling dates were 1, 5, 2, 5, 2, 5, 2, 3, 3 and 3. This finding is in accord with previous observations of the same kind, but with different times for the maximum and minimum effects. Though no

cause of variability has been established, movements of the herbicide and of carbohydrates may be suspected as being concerned. Refoliation usually follows the initial fall of old leaves of trees poisoned with 2,4,5–T, and it may be that individual variation in the timing and extent of defoliation and refoliation has an important bearing on the result.

In later inspections there were progressively fewer roots still alive, but the results for the shorter periods between poisoning and felling were still the least regular. Stump poisoning gave the most consistent results, which were equalled at the 15– and 18–month inspections by the longer periods (6 to 9 weeks) between poisoning and felling.

Crude starch determinations made on three roots from five stumps on each felling occasion, scoring the intensity of the colour developed with iodine in potassium iodide, showed the expected fall in starch content following poisoning, with a few reversals which might have been due to refoliation. However, no relationship could be seen between starch scores at the time of felling and the extent of death of the same stumps twelve months afterwards.

While much remains to be elucidated concerning the rates of death of roots of poisoned trees and the significance of the starch reserves in them, the practical conclusion emerges that it is satisfactory from the point of view of controlling root disease in a replanting to poison the old trees and fell them two months later.

Mechanical Clearing

An experiment to compare complete mechanical clearing with felling and poisoning the stumps, as the method of land clearing prior to replanting, was laid down in 1958 in Field 17 on the Experiment Station, superimposed on a Botanical Division cover crop experiment. Evidence of the superiority of clean clearing from the point of view of root disease incidence on the young stand is accumulating, but it is too early to conclude whether the method is economically and agriculturally justifiable.

A larger experiment of the same kind (L–60) sited on an estate near Kluang, Johore, compares four preplanting treatments (mechanical clearing with and without rooting, tree poisoning and stump poisoning) for their effects on growth and root disease losses in the replanting. Some difficulty has been experienced in establishing a uniform legume cover throughout the seventy acres of the seven replications. Root disease losses among the young seedlings, planted three at a point for field budding later in the year, have been of no consequence. Significant recording of root disease incidence can start only when the area has been thinned to one plant at each point.

Jungle Clearing

Experiment BP–60, sited in a new planting from jungle near Paloh, Johore, a district where *F. lignosus* infections have been particularly severe in the past, has three objects:

(i) to observe the effect of 2,4,5–T on jungle tree species;
(ii) to identify the jungle hosts of the root disease fungi;
(iii) to judge whether poisoning jungle trees prior to felling, as in replanting, has a similar beneficial effect on subsequent root disease incidence.

Observations bearing on the first objective have shown smaller trees to be more affected than large ones, but even in the smallest size group (girths 12–23 inches) more than half were apparently unaffected by spraying 5% 2,4,5–T round the trunk at a height of 4–5 feet until run-off occurred. A concentration of 10% 2,4,5–T gave better results, but even so two-fifths of the trees below 48 inches girth did not show changes in the foliage after 13 weeks, when the last observations were made. A factor that emerged clearly was the reduced effectiveness of the poison when applied to the base of the trunk of the larger trees, on which alone this modified method of application was tried. *F. lignosus* has started to appear on the young rubber, but it is too soon to draw conclusions concerning the primary hosts of the fungus, or to look for differences in incidence between the two poisoned and the two unpoisoned plots of the twenty-acre experimental area.

The Botanical Division, for the purposes of an ecological survey, has divided the area into quadrats which will also be of value in recording the positions of the stumps of identified jungle trees. A point plan of the area, which is contour planted, has been made as an aid to future recording.

Root Disease on Mature Trees

The effects of the major root diseases on mature trees are being studied on the Experiment Station in Field 42 North, where twenty-year-old trees were inoculated with the three major root disease fungi. Nine trees have so far been killed (*F. lignosus* 5; *F. noxius* 1 — wind snap; *G. pseudoferreum* 3) and a further five trees are going dry (*F. lignosus* 2; *F. noxius* 2; *G. pseudoferreum* 1). None of the dying trees has shown evidence of a flush yield. A slow diminution in yield may take place over six months or a tree may rapidly cease yielding within one month. Two *G. pseudoferreum* cases exhibited a fluctuation of yield, which decreased markedly during a dry season and increased to normal during a period of rain before ceasing abruptly. A slow loss of yield followed by a rise and then death may explain a generally held belief that all diseased trees give flush yields.

Early in the year a second tree count was made in experiment BP–61, where an attempt is being made to slow the spread of root disease in mature rubber by planting the open spaces with legume creepers, as compared with keeping the ground clean weeded. Legumes are not, however, readily established in partly shaded root disease patches.

Fundamental Studies of the Root Parasites

Pure culture inoculations of *F. lignosus* and *Polyporus zonalis* into lengths of tap root of young trees have confirmed the production of an undifferentiated rot by the former fungus and a pocket rot by the latter.

Cyclic saltation, referred to last year, has appeared in many isolates of *F. lignosus*. The reason for its increased occurrence remains unexplained, no cause having been found in the conditions of culture.

It has been found that a temperature of 60°F is about the lower limit at which growth of *F. lignosus* can be sustained, some cultures surviving and some dying out after 2 months. It is of interest to record that single spore cultures were more severely affected (25 lost out of 53) than were cultures derived vegetatively (7 lost out of 65).

A detailed study of *G. pseudoferreum* had been started in Fields 6, 16 and 18 on the Experiment Station, where the soils are broadly similar. The impression has been gained that an infection can be started with a smaller volume of inoculum than is required to establish *F. lignosus*. Broken sections of root penetrated by *G. pseudoferreum* are rapidly invaded by *Trichoderma viride*, yet *G. pseudoferreum* appears to be able to by-pass a section of root penetrated by another fungus, enclosing the entire root within its superficial mycelium. Further it appears that a young root may be in contact with a source of *G. pseudoferreum* for a considerable period before the source becomes active, the fungal skin needing to be broken by contact with the young root for the disease to be transferred.

Spore and Sporophore Production

Observations on sporophore and spore production have been continued in the laboratory and in an area on the Experiment Station where diseased stumps have been concentrated for the purpose. In the laboratory, two small but normal sporophores produced on rubber wood blocks from a pure culture of *F. lignosus* liberated abundant spores for about ten days, after which time the pores became blocked with a mycelial felt arising from the germination of undischarged spores — as happens naturally when the humidity is near saturation point. In the observational area at Sungei Buloh, many *F. noxius* sporophores were produced in quick succession, liberating spores for a few days only, before drying out. However, this contrasts with usual experience; other *F. noxius* sporophores, and those of *G. pseudoferreum*, have produced spores over periods of about 6 weeks. Ripe sporophores of the latter fungus have been seen to liberate spores discontinuously and in such numbers that they appeared to smoke, in puffs lasting about a minute.

Spore Colonisation of Stumps

In a further attempt to infect experimentally the stumps of felled rubber trees, their cut surfaces have been sprayed with suspensions of *F. lignosus* or *F. noxius* spores at a wide range of intervals after felling from half an hour to 64 days, starting with inoculations made immediately after felling, which was done either in the morning or the evening. *G. pseudoferreum* had to be excluded from the experiment because its spores had consistently failed to germinate despite many chemical and temperature treatments, storage for up to a year, or passage through the gut of an Erotylid beetle that feeds in the fructifications.

The area employed is ten acres of Field 2 on the Experiment Station. Felling started at the beginning of June. Five of the ten stumps in each treatment, have been sampled on two occasions by cutting away segments from the top, roughly 2 and 5 months after felling. Neither *F. lignosus* nor *F. noxius* has been recovered, but the principal saprophytic colonisers have been identified, as was planned as a subsidiary object of the experiment, a reference culture collection having been prepared to supplement identification from the appearance of the rot. In general, large stumps were less rapidly penetrated than small ones—a finding consistent with field observations on the rate of decay; and, as was expected, poisoned stumps were much more quickly invaded than unpoisoned ones. In connection with this investigation, a study of the micro-anatomy of rubber wood is being made in collaboration with the Botanical Division.

A part of Field 14 (the western half of C and D) is being used for observations on the natural colonisation of stumps by spores. At the time of felling, in 1960, the stumps were treated to a varying extent with creosote — applied to the cut only, to the whole of the stump, or to the sides only — or were not creosoted. The area was planted with seedlings for budding in the field a year later. Quarterly rounds of root disease inspection have started, but very few cases have been recorded yet. A related experiment was put down in Field 21 in 1960 to compare creosote with three concentrations of pentachlorophenol dissolved in diesel fuel oil.

DISEASES OF THE TAPPING PANEL AND STEM

Several cases of brown bast have been observed to have internal rots in the trunk, not always evident macroscopically. Organisms obtained in culture from the wood, include species of *Fusarium* and *Ceratocystis* as well as several unidentified fungi (one a yeast) and bacteria. Most specimens so far examined have shown check-rings or other evidence of earlier invasion of the wood, sometimes associated with wounds. It is not known to what extent this phenomenon can occur in healthy trees as a sequel to the wounding that may arise in normal estate practice, or as a sequel of the death of feeding rootlets. A Gram-negative motile bacterium was obtained in isolates made from the inner bark and outer wood of a tree in which brown bast had been experimentally induced by the Botanical Division by intensive tapping.

A striking feature observed in sections of brown bast material obtained from another site was the degradation of cells in the medullary rays. Disintegration of the nucleus appeared to precede an irregular thickening of the cell wall, which developed peg-like inward growths finally forming branched structures partly obliterating the lumen of the cell. Evidence of the presence of bacteria in the latex vessels was obtained by dissolving rubber from sections of brown bast bark with minute quantities of xylol, which was allowed to evaporate on clean microscope slides. Staining the slides revealed both Gram-positive and Gram-negative bacteria.

Phytophthora

An outbreak of 'black stripe' in Field 48A in the Experiment Station that occurred during January was unusual in that there was little fissuring of the renewed bark, which in some cases was nearly all dead, and the underlying wood lacked the typical black stripes. Moreover, the attack had extended above and below the panel to the untapped bark, where it produced symptoms somewhat resembling those of 'patch canker'. While clones in neighbouring plots bore only traces of damage, which was limited to the renewed bark, a plot of clone RRIM 609 was severely damaged. The extreme reaction of this clone could be due to its susceptibility to the pathogen combined with its known abnormally sensitive response to wounding.

Mouldy Rot

No proprietary materials have been submitted for test.

LEAF DISEASES

Bird's Eye Spot

Weekly fungicidal spraying against bird's eye spot in a nursery in Field 2 on the Experiment Station was continued from last December until the end of June. The six treatments—five fungicides and untreated controls — were replicated six times on 1/24-acre plots. Treatment effects were assessed first by weighing sets of twenty plants, later by counting the number of buddable plants per plot. A fungicide that contained mercury as well as copper had to be dropped from the treatments because of the stunting it induced. Three of the other four treatments gave significantly greater weights of plants than the control but, when analysed on the basis of the numbers of buddable plants, the differences were no longer significant.

Other Leaf Diseases

An outbreak of powdery mildew on *Croton hirtus* being grown in the Soils Division glasshouse as an indicator plant in two soil samples provided an opportunity to relate the nutritional status to disease incidence. The species of *Oidium* involved has spores smaller than those of *Oidium heveae.* The most striking result was that magnesium-deficient plants were hardly affected by the disease.

PESTS

Termites

A 0.05% emulsion of heptachlor at the rate of 1 pint per tree has been found effective for the treatment of termites attacking young rubber in ordinary soils; in peat, good persistence can be achieved by a fourfold increase in concentration.

Cockchafers

Ultra-violet light traps have been operated on four estates where there have been repeated infestations of *Holotrichia bidentata.* Peak flighting activity, in March, coincided with wet weather after a dry period. The beetles have been found to feed on the foliage of fifteen species of jungle trees and five cultivated trees. A rather poor recovery of marked beetles released to judge the effective range of the traps drew attention to the fact that many beetles attracted to the trap stopped short of it, alighting on the illuminated foliage. Possible improvements in trap design are being considered. *H. bidentata* grubs have been reared in the laboratory from eggs taken from mating females, to ascertain their feeding habits and the lengths of the developmental stages. First stage grubs fed only on dead vegetable matter; in the second stage on living roots, but not of rubber; only in the third stage were rubber roots taken, and even then the grubs preferred roots of *Pueraria phaseoloides.*

For the second time, two years after treatment, soil samples have been taken from around trees treated with 0.1% heptachlor or aldrin emulsions in August 1959, for bio-assay with grubs of *H. bidentata,* which were killed in 8 and 18 days respectively.

Other Pests

Specimens of the mite predator *Typhlodromus newsami* having been collected and reared to provide a supply for overseas shipment, the opportunity was

taken to make observations of their feeding habits. Though preferring to feed on the yellow tea mite (*Hemitarsonemus latus*) it also took all stages of *Paratetranychus citri* and *Eutetranychus orientalis*, the species of *Brevipalpus* that are found on rubber leaves, and *Tetranychus telarius* which is not. *Paratetranychus hawaiiensis* was taken reluctantly, and only when its web was damaged. The predator becomes visibly reddish (from the gut contents) when feeding on these red mites; that they are frequently found to be similarly coloured in the field, suggests that they feed on *Tetranychids* or other red mites under natural conditions.

PESTS AND DISEASES OF COVER PLANTS

Insecticide Tests

Sevin, a new carbamate insecticide, was compared with DDT, endrin and diazinon for the control of *Epilachna indica* and *Lamprosema diemenalis* on the Experiment Station. The rates of application were respectively $1\frac{1}{2}$, $1\frac{1}{2}$, $\frac{1}{8}$ and $\frac{1}{2}$ lb per acre of the active ingredient. Against the ladybird beetle, Sevin was comparable in its effectiveness with DDT, but it had a greater knock-down effect. Endrin and diazinon were earlier proved to be inferior to DDT against this pest. All four were effective against the caterpillar, but endrin was best and DDT the next best in delaying re-infestation.

Fungicide Tests

Because of the frequent occurrence of die-back of legume creepers caused by *Rhizoctonia*, a small test has been made to compare Bordeaux mixture with three proprietary fungicides in wettable powder form, applied with a mist blower at the rate of 40 gallons per acre. The best results were obtained with ferbam at the rate of 3 lb active ingredient per acre, fortnightly applications giving complete control and monthly applications fair control. Less effective were 8: 10: 40 Bordeaux mixture, a dispersible copper fungicide applied at the rate of 2 lb copper per acre, and pentachloronitrobenzene at the rate of 10 lb per acre.

MISCELLANEOUS

Rhizobium Culture for Legume Inoculation

Monthly routine testing of *Rhizobium* strain 272C, distributed for the inoculation of *Centrosema pubescens, Pueraria phaseoloides* and *Calopogonium mucunoides* has continued in turn on the three covers named. Effective nodules have continued to be produced on the three covers within about a month of inoculation, inoculated plants developing green leaves and growing well, in strong contrast to the uninoculated controls given only the same nitrogen-free nutrient. Twenty thousand packets of *Rhizobium* compost culture have been distributed during the year.

Arrangements have been made for *Rhizobium* antisera to be produced in Singapore, to investigate the possibility of employing serological methods to check on the field establishment of inoculated strains.

Mycorrhiza

Evidence has been obtained of the widespread occurrence of a vesicular-arbuscular mycorrhiza in lateral roots of young rubber plants and in the feeding

roots of mature trees. A number of fungi of unknown significance have been isolated from such roots.

Minor Root Rots

Seven isolates of fungi obtained from dying or dead small roots of young field plantings have been used to inoculate one-year-old seedlings growing in a greenhouse. The inoculum for each pot was three petri dish cultures of the fungus on malt extract agar, macerated in 200 ml of sterile water and mixed into the top 4 in. of the soil. A certain amount of root injury occurred inevitably; in addition, the tap roots of the four to five plants in each pot were intentionally wounded. One control pot for each fungus received the same treatment except that the malt extract agar was sterile; a second control was watered with 200 ml of sterile water. After two months, four of the seven introduced fungi were recovered from lesions of the roots, and also a species *Fusarium* which had not been introduced.

Investigations of minor root rots and the mycorrhizal association, related in that they both involve root-inhabiting fungi, are being jointly pursued.

ADVISORY

Though no longer directly responsible for advisory work, the Division continues to receive many specimens for identification. Complete records of such enquiries are no longer kept, but certain unusual occurrences are set out below together with notes on *ad hoc* investigations.

A heart rot extending a foot or two above ground in the centre of the stem of a tree in experiment SR-57 has been found, by isolation of the fungus, to be caused by *Ustulina zonata*, though the typical black lines were lacking. A case of similar penetration by *G. pseudoferreum* has been observed in a tree in experiment J-57 which showed no foliage symptoms although its tap root had been completely killed. Tap root infections with relatively little involvement of the lateral roots seem to be rather typical of *G. pseudoferreum*.

A close watch has been kept on the spread of *F. lignosus* on a bush cover of *Flemingia congesta* on an estate in Johore where root disease has been a serious problem. During the flush growth of regeneration after slashing it is possible to detect dead bushes, but it has been found not to be a sensitive indicator of the spread of infection.

A die-back of pollarded RRIM 501 on an estate was found to be associated with *U. zonata, F. noxius* and an unidentified fungus. In some cases where trunk snap had been treated by pollarding, die-back had later killed the tree.

A fungus resembling *Pellicularia filamentosa* (Pat.) Rogers—the cause of target leaf spot in the Americas and recently described as causing a like condition in India—has been found in the mist propagation unit on the Experiment Station and on *Calopogonium caeruleum* specimens received from an estate in Kedah.

In addition to eight known outbreaks of cockchafer grubs *(Holotrichia bidentata)* on plantations in Negri Sembilan, Malacca and Johore, *Leucopholis rorida* and *Lepidiota stigma* have been identified amongst specimens received from two

plantations in Kedah and one in Perak, while *Psilopholis vestita* has been encountered on a plantation in Johore. A high mortality of beetles emerging in an area that had been given a surface insecticidal treatment indicated that chemicals may provide a means of reducing the beetle population, as well as light traps.

A Diaspidid scale insect has been newly recorded, on an estate in Negri Sembilan, feeding on the underside of mature leaves of one and two-year-old trees along with four known species. The infestation was severe and extensive, but there were indications that the trees had first been weakened by some other agency, predisposing them to attack.

Taeniothrips minor has been recorded as feeding at the base of the petiole in the region of the terminal bud of young plants in the field. The evidence of their feeding, in the form of corky patches at the site of feeding, becomes evident when the leaves open out.

Visits

During the year, Research Officers made 21 visits to estates and smallholdings for advisory purposes, and two senior Field Assistants between them visited 35 estates or holdings to instruct pest gangs on the control of root disease.

Lectures to Planters

Four lectures on pathological subjects were given to branches of the Incorporated Society of Planters at Johore Bahru, Kluang, Malacca and Sungei Patani.

Training

Demonstrations and lectures on the diseases and pests of rubber, and their control, were given as part of a course for Estate Assistants, four courses for Senior Conductors, two courses for prospective Assistant Rubber Instructors of the Smallholders' Advisory Service, and one course for students of the College of Agriculture, Serdang.

A. Newsam
Head of Pathological Division

Chemical Division

The position of natural rubber in world markets is now being challenged on a technically more effective basis than ever before. This arises from the decision to produce commercially considerable quantities of stereo-regular rubbers, which offer the consumer advantages provided by no earlier general purpose synthetic rubber, and approach natural rubber very closely in certain important properties, surpassing it in others.

The technology of natural rubber preparation is essentially the concern of the Chemical Division, and the investigations it carries out must take account of the commercial status of natural rubber, particularly in respect of technical properties. Research investigations carried out by Division have thus been aimed at meeting competition from synthetic rubbers, and may briefly be described as comprising two major aspects, (a), improvements in the technology of preparation to give increased yields, and more efficient operation of factory processes in order to lower costs of production and (b), a greater understanding of what is obtained from the tree in the form of latex and how to produce from it materials having improved properties which suit consumer requirements.

A brief statement of the more important aspects of the Division's work follows in four sections, Fundamental Research, Applied Research and Technology, Process Evaluation and Factory Studies, and Advisory and Technical Services.

FUNDAMENTAL RESEARCH

BIOCHEMISTRY

Fractionation of Fresh Latex

Studies on the fractionation of fresh latex have been undertaken during the past five or six years with the object of separating into identifiable components the highly complex system discharged from the tree on tapping, which we now regard as comprising part of the cytoplasm of the latex vessels. Earlier work indicated that latex from different trees gave much the same pattern of layers or zones when collected and centrifuged at high speed under standard, refrigerated conditions. The zones have been labelled and are now quite readily identified, particularly when examined after treatment with vital stains, such as Janus Green B, (e.g. Zone 7, *Figure 1, RRIM Annual Report 1960,* page 72). It is of interest to record that certain of the zones (7, 8 and 11) show colour changes when incubated at 30°C, thus indicating the presence of materials capable of reducing the dye.

More recent studies using the light microscope have shown that certain of the zones are not visually homogeneous, but are composed of particles, differing in type and proportion.

The main purpose of the high speed centrifugation studies has now been achieved since a technique for separation of fresh latex into identifiable zones is now well established. The emphasis of the work has now shifted from examination of the zones to studies of the particles comprising them; this work is described below under Studies on Latex Particles.

Latex Proteins

Attempts to examine latex protein were originally undertaken as part of a basic programme to obtain more information on the nature and function of the non-rubber constituents of latex and the transformations they undergo after latex leaves the tree. The high speed centrifugation technique described in the previous section has proved a very useful means of providing different fractions, two of which have been examined for protein components.

Proteins in the bottom fraction obtained from high speed centrifuging have been examined by paper-electrophoresis, and the presence of some eight components has been demonstrated. The electrophoresis patterns given by latices derived from four different clones were remarkably similar, differences consisting in the intensity of the bands; certain of the components appeared to occur at low concentration or were not observable in some clones. Experiments are now in hand to determine the effect of opening a new tapping cut on a tree in regular tapping and to follow any seasonal changes which may occur during the subsequent twelve months. The present indications are that opening a new panel gives a latex with the pattern of protein components already established.

Proteins in the serum fraction separated by high speed centrifugation (known as C serum), were found more difficult to resolve by techniques of paper electrophoresis, but clear separation has been achieved by the use of electrophoresis carried out in gels made with Connaught starch. A standard method has now been evolved which gives reasonably reproducible results. Latex taken from the same trees at an interval of about one year shows patterns which agree very well. At present twenty-two bands have been established, five representing cationic components and 17 representing anionic ones. Work is now in hand comparing latex from four different clones, RRIM 501, Glenshiel 1, Pilmoor A44 and Tjirandji 1, making collections over a period of a year. The patterns obtained from these clones resemble closely the earlier ones obtained from mixed seedling trees, but additional bands have been observed in certain clones. Present evidence indicates that differences of a quantitative nature between clones are more marked than variations due to seasonal changes.

Non-protein Nitrogenous Constituents of Latex

Work in this field has been directed largely to an investigation concerning those substances naturally occurring in rubber which act as accelerators of vulcanisation in mercaptobenzothiazole formulations.

Preliminary studies based on semi-quantitative chromatographic analysis led to an examination of the degradation of latex phosphatide by a choline-releasing enzyme, previously reported by Smith working at the R.R.I.M. in 1954. It has now been shown that inhibition of this enzyme during preparation of rubber coagulum by acidifying to about pH 4.5, results in a greatly increased accelerator content of the rubber, as compared with rubbers prepared without inhibition of the enzyme. Addition of choline or crude latex phosphatide to a normally coagulated rubber also confers fast curing properties. This work suggests that the vulcanisation characteristics of natural rubber can be markedly influenced by the activity of a phosphatide splitting enzyme, which may be of considerable importance in relation to the variability of commercial supplies of natural rubber.

MICROBIOLOGY

Bacteriological Counting

Estimation of the number of viable bacteria in a sample of latex has been found to be an operation requiring great care; this arises partly from the nature of latex itself which provides a highly nutritious substrate, and partly from the fact that the number of bacteria present may range from almost zero to hundreds of millions. Improvements and refinements in methods of testing are constantly being sought and recent studies have compared different liquids for dilution purposes, including glass distilled water, isotonic saline, Ringer's solution and serum from sheet production. The value of these liquids for dilution differs according to the type of material under examination, which suggests for example that it may be more profitable to use one system for ammoniated latex concentrate and another for ammoniated field latex. The importance of time of incubation after plating also differs with the type of material examined. Operators' errors within a given laboratory appear to be small and at present are not statistically significant.

The techniques for viable counting used so far have employed the standard pour-plate method (in petri dishes) and Astell tubes. Experiments have now been carried out using the surface drop technique which although providing only fully aerobic conditions for bacterial growth offers a number of advantages since colonies are more easily counted and identified, and considerable economy of time and materials is obtained. Preliminary trials indicate that the method compares favourably with those in use at present and a statistically designed experiment is now in hand to confirm these findings.

Methods for assessing the yeast population of field latex are also being studied in view of the observation that rust on smoked sheet is associated with such microorganisms, and that field latices under certain specialised conditions show heavy yeast populations. Two yeasts found in field latex from an estate in Pahang have been identified by Dr Brady of the National Collection of Yeast Cultures in England as *Saccharomyces carlsbergensis* (Hansen) and *Trichosporon fermentans* (Diddens and Lodder).

Bacteria in Latex

Experiments have continued in co-operation with the Latex Technologist to assess the value of a wide range of substances as bactericides in latex. An additional test procedure has now been introduced in which latex concentrate, preserved with a given combination of reagents, is re-contaminated with bacteria three months after preparation, to see if initially satisfactory systems retain their properties and can cope with subsequent introduction of an inoculum. The test is designed to imitate conditions likely to occur during commercial production and shipment of latex concentrates. The initial trials with this method indicate that some bactericides considered as good preservatives are not capable of dealing with fresh inocula after the three-month storage period. Further investigations are necessary before definite conclusions can be drawn.

In order to speed up the screening of possible bactericides for use in latex concentrates, experiments have been made to determine whether the initial rate of kill of bacteria in field latex provided by a given substance could be used as an index of its longer term behaviour in preserving latex concentrate. Further work is needed before definite conclusions can be drawn.

Treatment of Trees by Bactericidal Atmospheres

An interesting series of experiments have been carried out in which *Hevea brasiliensis* trees were treated with bactericides in the gaseous state. For this purpose, some four to five feet of the tree in the region of the tapping panel was surrounded by a loose fitting cover of polythene sheet, into which the bactericides were introduced. Ethylene oxide and ammonia each resulted in a marked increase in latex flow, but caused bleeding and severe damage to the cambium. Formaldehyde gave a smaller increase in latex flow, the area of cambium damaged being much less. Patent protection has been sought covering a method of providing gaseous atmospheres around the tree.

Field trials applying antibiotics and bactericides to the tree have been carried out in co-operation with the Botanical Division (see under Botanical Division, p. 63).

Brown Bast

Investigations have been continued in co-operation with the Botanical and Soils Divisions attempting to determine whether bacterial contamination is associated causatively with brown bast conditions in the rubber tree. Progress in this work will not be reported this year as investigations are being actively pursued but are not complete.

Utilisation of Waste Serum

A brief examination has been made of the possibility of growing yeasts and fungi on serum obtained as a by-product of sheet rubber manufacture. It was found possible to culture a number of different strains of yeasts with little difficulty, and to grow certain types of fungi, e.g. two strains of *Psalliota campestris*. These findings have been discussed with a commercial organisation interested in utilising serum for the production of cattle food in the Federation. Further studies are in hand attempting to find a yeast capable of utilising quebrachitol, in co-operation with the National Collection of Yeast Cultures in England.

STUDIES ON LATEX PARTICLES

Microscope studies on latex. Further work using time-lapse photography and staining techniques have confirmed observations reported in the previous *Annual Report* on the complex system of particles and threads present in latex freshly excised from the tree. The thread-like processes observed in *Hevea brasiliensis* latex show more extensive ramifications than were seen earlier.

Brief investigations on very fresh latices from material other than *Hevea* have confirmed the presence of 'lutoid' particles in all species of lactiferous plants examined, covering eight families and twenty genera. In *Manihot dulcis* (Euphorbiaceae) the lutoid type particles form the dominant disperse phase, and under the phase-contrast optical microscope appear morphologically similar to those of *Hevea brasiliensis*.

Chemical studies of 'lutoid' particles. Starting with the bottom fraction obtained by high speed centrifugation of fresh *Hevea* latex, it has been possible to isolate a portion consisting substantially of 'lutoids' (Zone 8), and to break this down into two sub-fractions by the use of non-ionic detergents and ultrasonic vibration. The

sub-fractions are separated by further centrifuging and comprise a solid portion, referred to as a pellet, and a sludge of extremely fine particles.

Judging by appearance under the light microscope, the pellet could consist of compacted wall material from disrupted lutoids; the sludge could equally well be the interior particles of the 'lutoid' fraction, set free after breakdown of the retaining wall.

Both pellet and sludge contain lipids and protein, the pellet having a higher proportion of protein and less lipids than the sludge. Both sub-fractions contain ribonucleic acid, but no deoxyribonucleic acid has been detected in either. Both sludge and pellet contain an appreciable quantity of rubber, (up to 12 per cent has been observed) which, however, is only released in a free form after hydrolysis with warm alkali.

Electron microscope studies. A Philips 100B electron microscope was received at the end of May and was at once set up and commissioned for a programme of work on the distribution of particle size in latex.

Considerable attention was given to the problem of sample preparation, which although basically simple, required some effort to obtain specimens which were representative and at the same time gave well dispersed particles as against agglomerates. Satisfactory techniques have now been acquired and the particle size distribution of fresh field latex from clone Tjirandji 1 has been worked out, attention being paid to the statistical aspects of the sampling procedure. A comparison with the distribution of a large-particle synthetic latex determined in the same manner demonstrates clearly the large number of very small particles naturally occurring in *Hevea* latex (See *Figure 3*). Future work in this field aims at modifying the particle size distribution of natural rubber latex by inducing agglomeration of the particles to give a product with larger average particle size, which it is hoped may show improved behaviour in the manufacture of latex foam rubber and other applications.

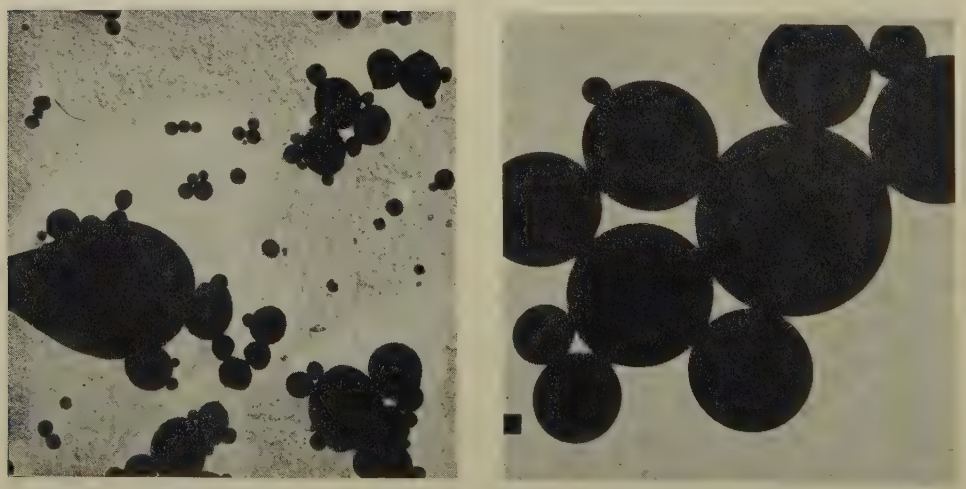


Figure 3. Electron micrographs of (left) natural rubber latex (from clone Tjirandji 1) and (right) a large-particle synthetic cis-polyisoprene latex. Very small particles are rare in the synthetic latex.

POLYMER CHEMISTRY

Physico-Chemical Changes in Fresh Rubber

Investigations carried out over the last two years have indicated the presence in rubber of reactive centres having aldehydic functions. It was demonstrated that on storage of fresh rubber or by an accelerated ageing test in which the rubber is heated over a powerful desiccant such as phosphorus pentoxide *in vacuo* for 48 hours, the naturally occurring active groups were involved in a cross-linking reaction which increased both the gel content and the hardness of the rubber. If the active groups were first reacted with a carbonyl reagent, for example a monofunctional primary amine, no appreciable cross-linking or hardening occurred. Similar centres were not found in synthetic rubbers such as styrenebutadiene copolymer, *cis*-polyisoprene or *cis*-polybutadiene. These observations suggest that natural rubber may not be a simple polyisoprene, and work is in hand attempting to establish whether the aldehyde groups form part of the rubber hydrocarbon molecule. If so, it is hoped to determine more precisely the nature of the groups and their relation to the polyisoprene chain.

It has now been demonstrated that fresh rubber in solution also shows the cross-linking reaction when heated at 140°F for 48 hours, provided care is taken to prevent oxidation. The increase in intrinsic viscosity observed was almost completely inhibited by the addition of a carbonyl reagent, hydroxylamine.

As reported already, reacting rubber with bi-functional amines increases the hardness, presumably by building cross-links between two aldehyde groups. Experiments have now been extended to include hydrazine, which gives rise to an increase in Mooney viscosity as expected, but shows some anomalous features now being investigated.

The above observations indicate a means of maintaining constant the plasticity of raw rubber simply by reacting the rubber with carbonyl reagents. Monofunctional amines inhibit cross-linking and so maintain the Mooney viscosity at the value obtaining immediately after preparation. Poly-functional reagents increase the hardness to a limited extent, after which no further change occurs. Smoked sheet rubbers prepared using each of these principles have been shipped to the United Kingdom with no change of Mooney viscosity during shipment. Technological evaluation of these rubbers is now being carried out at the Natural Rubber Producers' Research Association.

Although the reaction between naturally occurring carbonyl groups in the rubber hydrocarbon with added amines is readily explained, the condensation reaction which appears to occur when fresh rubber is heated *in vacuo* requires the presence of other reactive groups also naturally occurring. It is still a moot point whether this second type of group is attached to the rubber molecule or whether a bi-functional carbonyl reacting substance is present in latex and brings about the naturally occurring cross-links in a manner similar to that shown by added poly-functional amines.

Attempts to demonstrate the presence of aldehyde condensing groups has established that hardening of rubber can be inhibited by reacting it in the latex form with a number of aldehydes, such as glyoxal, dextrose, lactose, glyceric aldehyde, and so on. The amount of reagent required to render inactive the aldehyde condensing groups of rubber, suggest that up to 400 of these groups are present per

molecule of rubber (molecular weight 1,000,000). The numbers observed differ with rubber from different clones, and in one experiment the values obtained ranged from 111 for PR 107 to 378 for PB 5/63; Tjir 1 and PB 86 both gave values of 211.

It is interesting to note that glyoxal which is a bi-functional aldehyde behaves only as a mono-functional reagent. This can be explained in different ways, one of which is that the aldehyde condensing groups are not attached to the rubber. Conflicting with this view is the fact that observations on the degree of hardening obtained by heating rubber alone *in vacuo* has always shown considerably higher values (maximum Mooney Viscosity 140) than can be produced by added bi-functional amines (maximum Mooney Viscosity 110). This suggests that one aldehyde group is cross-linked with another reactive group in the hydrocarbon chain in the natural hardening process, whereas two aldehyde groups are required to form a cross-link when diamines are used. The problem obviously requires further investigation.

In connection with this work some interesting observations were made on rubber obtained from newly opened and from rested trees during the first few weeks of tapping. Measurement of gel content of the rubber confirmed earlier observations that as tapping proceeds the amount decreases from over 60 per cent to 10 per cent or less, after ten or twelve tappings. During the same period the number of aldehyde reacting groups per molecule of rubber increased from 4 to 35, and the number of aldehyde condensing groups from 200 to about 400. This work will be presented as a paper at the Rubber Technology Conference in London, May, 1962.

Methyl Methacrylate Graft Rubbers

Earlier work has shown that by using a multi-stage grafting operation instead of single stage grafting, products with different molecular configuration and improved technological characteristics can be obtained. Attempts to convert the multi-stage grafting process to a continuous one have not been successful. No further investigations at bench level are contemplated at present. Commercial application of MG rubbers is discussed under 'Process Evaluation and Factory Studies'.

Hydrazine-Formaldehyde Resin Latex

Hydrazine reacts exothermically with formaldehyde to form a resin, the reaction being violent unless the reagents are diluted by a suitable medium. Trials in which the reactants were both added to latex concentrate showed that the reaction could readily be controlled, and indicate that part of the resin formed may be chemically integrated with the rubber. The resulting latex has been shown to give foam rubber and films with improved properties.

The reagents are used in the proportion of one molecule of hydrazine to two of formaldehyde. In foam rubbers from natural latex, prepared at the same density, compression modulus before and after fatiguing and also after 22 hours ageing at 100°C showed approximately 10 per cent better values after incorporation of 2 – 3 per cent of hydrazine formaldehyde resin. Vulcanised films showed 25 per cent better tensile strength, double the modulus and 50 per cent better tear

strength when prepared with latex containing resin. Only marginal improvements were conferred on SBR latex foams. An application for patent protection has been filed in respect of this process.

APPLIED RESEARCH AND TECHNOLOGY

ANALYTICAL METHODS

A big effort has been made to modernise our analytical methods and laboratories by employing instrumentation where necessary. During the year a total of nearly 44,000 determinations were carried out, covering routine work and *ad hoc* investigations for research officers in the Chemical and other Divisions, and routine testing for estates and for our Technical Advisory Service to local rubber manufacturers. The work of the analytical section takes about fourteen per cent of our total manpower and the volume of work is increasing year by year. New instruments received during the year include a Perkin-Elmer flame photometer, a Hilger-Watts large quartz spectrograph, a Perkin-Elmer infra-red spectrometer and a Beckman gas liquid chromatograph. Laboratories have been set up and operators are now being trained to use these instruments, which should result in a more efficient use of the staff concerned. It is hoped to start building the new radiochemical laboratory during 1962, which when in operation should greatly assist research work currently being carried out in the Chemical and other Divisions.

Development of test methods recently carried out in the analytical laboratories include a modified test for determining hydrogen sulphide in latex, and confirmation of earlier work that the use of chloroform, as specified in the B.S.I. method for copper determination in rubber, is not satisfactory in tropical climates and can with advantage be replaced by iso-amyl alcohol.

LATEX TESTING AND TECHNOLOGY

Test Procedures

Renewed interest has been shown in the Latex Strainability Test (Brass and Slovin) since certain consumers of latex concentrate have imposed strainability limits in their purchasing specification. Factors affecting this test have been examined and it has been shown that latex with a high degree of strainability can be produced by storing field latex ammoniated to 0.3 per cent for at least 24 hours before centrifugation. Unfortunately such a practice adversely affects other properties, particularly the chemical stability (ZOT and ZST Tests). No satisfactory solution has been found so far to the problem of producing a latex with both high strainability and high chemical stability.

A considerable effort has been made in compiling data to establish the relationship between specific gravity of latex concentrate and temperature. The specific gravity of latices ranging in dry rubber content from 58.00% to 62.00% was measured at different temperatures between 4°C and 40°C, and regression equations for specific gravity on dry rubber content were computed at each temperature. An analysis of variance of the slopes of these regressions showed no significant differences between them. A common slope was then derived and permitted

the establishment of a specific gravity—temperature relationship at 60.00 per cent d.r.c. as follows:

$$S_t^t = 0.955685 - 0.000466t + 0.000004t^2,$$

where S_t^t is the specific gravity at any temperature t°C.

The ZST test (Newnham) has been compared with the mechanical stability test (A.S.T.M.) in the routine testing of latex concentrate samples. Statistical examination of the data is in hand and preliminary results indicate that the ZST values of natural rubber latices decrease to a constant level on storage. No correlation between the ZST test and the mechanical stability test was established.

Latex Preservation

A number of substances, about thirty in all, have been evaluated as secondary and tertiary preservatives for latex concentrate, used in conjunction with a low level (0.2 per cent) of ammonia. A number of these systems appear to be satisfactory from the bactericidal point of view and the more promising ones have been selected for evaluation on a technological basis for the preparation of foam rubber and other latex products. This work is in hand, but is proceeding slowly due to restricted testing facilities.

It may be of interest to mention a series of laboratory experiments which have confirmed commercial experience that behaviour of concentrate on storage is influenced by the type of container used. The cause for this is not apparent but may be due to bacteria and as described under Microbiology, experiments are in hand examining the effect of recontamination with an inoculum after three months storage.

A brief examination was made of the value of different surfactants in stabilising two commercial types of latex concentrate. From a selection of 18 different materials tried, lauric acid was found to be the most effective and economical stabiliser for normal ammoniated latex concentrate; unlike most other materials examined, lauric acid retained its effectiveness for a period of six months after preparation. Lauric acid was also found to be the most effective and economic stabiliser for low ammonia latices containing zinc diethyl dithiocarbamate (ZDC).

Effect of Manuring on Latex Properties

Two experiments on commercial estates have been carried out in connection with trials arranged by the Soils Division, in an attempt to determine the effect of the more common fertilisers on latex composition and properties.

On the first estate, PB 86 trees growing on a shale-derived soil, were the subject of a 3^3 NPK fertilisation experiment, consisting of 27 plots (Experiment No. SE 29/2), which was started in 1958. During the first year, the nitrogen content of the latex total solids showed an increase of about 6 per cent nitrogen, following ammonium sulphate fertilisation, and the potassium content showed an increase of about 6 per cent following treatment with potassium chloride. An increase in the phosphorus content of about 25 per cent was found during the second year, following rock phosphate treatment. Once established, these levels were maintained throughout the remainder of the four-year period of observation. No appreciable effect on latex concentrate properties was established, seasonal changes

following the normal pattern, irrespective of fertiliser treatment. Further investigations by Chemical Division will now be reduced to one series of latex tests per year.

On the second estate, RRIM 501 trees growing on a granite-derived soil, were subjected to a 2^4 NPKMg fertiliser experiment, with three replications, comprising 48 plots (Experiment No. SE 52). This trial was started in 1959, but unfortunately has been seriously interfered with by wind damage, causing loss of trees in the experimental plots. The estate management decided to increase tapping intensity at the beginning of 1961, using a high as well as the original low cut. The experiment as originally planned was thus terminated.

In these trials no effect on composition of the field latex was produced by potassium chloride or magnesium sulphate treatment. An increase in nitrogen content of about 6 per cent was observed in the second year, in response to ammonium sulphate, and an increase of about 20 per cent in phosphorus content following rock phosphate treatment. These levels once established were maintained throughout the period under observation, although the phosphorus content showed some fluctuations. On this estate, where at the commencement conditions were more favourable for precise observations, a significant negative correlation between ammonium sulphate treatment and mechanical stability time (A.S.T.M.) of latex concentrate prepared from the field latex was established after the first year. The change in M.S.T. was not great, the value falling from 400 to 300 seconds after one month's storage of the latex concentrate and from 1,000 to 900 seconds after 3 months' storage. The effect once established was maintained. No correlation between fertiliser treatment and viscosity or KOH No. of the latex concentrates was found. Further observations studying the effect of fertiliser treatment on latices from high and low cuts were made during 1961; the data are now being analysed. The experiment has now been concluded as a further change in the tapping system has recently been introduced.

Latex Foam Rubber

For the purpose of comparing different types of latex for foam rubber preparation, a ready means of assessing optimum cure is required, since certain preservatives have an effect upon the rate of vulcanisation. Compression modulus at 25 per cent compression and equilibrium swelling in toluene were found to be valuable parameters for this purpose.

A comparison of current commercial types of latex concentrate, including preservation systems based on 0.7 per cent ammonia, and three based on low ammonia content with boric acid, sodium pentachlorphenate and zinc diethyl dithiocarbamate respectively, showed only small differences between them, none being outstandingly better than the others.

Various types of natural rubber (NR) concentrates were also compared as blends with a styrene-butadiene synthetic (SBR) latex (Intol 62A) for foam rubber preparation. The NR types comprised (a), preservation with 0.7 per cent ammonia, (b), low ammonia and boric acid, and (c), low ammonia and ZDC.

It was at once apparent that the properties of foam prepared with NR/SBR latex blends do not follow a simple law of mixtures based on the properties of foams prepared with the two component latices; for the most part the properties were inferior to those of either of the component latices. An exception was found

in the case of boric acid latex, when the curve plotting compression modulus against proportion of NR to SR approached the line joining the values for the individual components. Differences in properties conferred on the blends by the various natural latices were marginal, save in the case of boric acid latex, which showed a little higher compression modulus and rather better resistance to ageing.

Another series of experiments compared the processing behaviour and properties of foams produced from five commercially available high-solids styrene-butadiene latices and their blends with ammoniated latex concentrate. The compounding formulations used were modified slightly to suit the requirements of the particular synthetic latex under investigation.

Differences in the processing characteristics and in the properties of foams produced from the five SBR latices were observed, one appearing to have the best all round properties and to be as good as or even better than natural rubber latex, particularly in respect of compression modulus. In all cases, however, natural rubber foams showed superior tension strength and elongation at break.

In blends with natural rubber latex, the best of the synthetic latices again gave the best results. For most properties, however, blends of NR and SBR showed inferior properties to those of foams prepared with the individual component latices. An exception to this is the observation that foams prepared with a small proportion of natural rubber showed lower fatigue loss, lower static compression set and in some cases better ageing than the synthetic latices alone.

The above observations on mixtures of natural and synthetic latices for foam rubber production require considerable care in interpretation since experience has shown that behaviour in the factory can be very different from that observed in the laboratory. The data are of value, however, since they suggest lines of study to be followed up in co-operation with manufacturers.

Attempts have been made to prepare foams with improved compression modulus by incorporating a proportion of prevulcanised latex with different types of NR latex and with one NR/SBR latex blend. An increase in compression modulus was found, the value lying in the range given by china clays, lithopone and 'Mica W', a commercial grade of mica. Increase in tension strength and decrease in age hardening were also obtained. No adverse effect on processing was observed. The advantages gained, however, were not sufficiently great to justify the increase in cost involved and the practice is thus thought to be uneconomical.

RUBBER TESTING AND TECHNOLOGY

Test Procedures

A gas permeability testing apparatus has been constructed and is now being used for routine testing of vulcanised rubber intended for the manufacture of articles such as the inner tubes of tyres.

The test employed for quality control of SP and PA 80 rubber production has been under consideration for some time, since the present method, a simple extrusion, is time-consuming. A mill shrinkage test has been examined as an alternative method, since it would be quicker to operate and might have advantages in requiring no specialised equipment. Unfortunately the mill shrinkage test has been found to be unreliable owing to operator differences, which so far cannot be attributed to tangible causes. Further work on this test has therefore been shelved

and efforts at present are being directed towards improving the present extrusion test to permit quicker operation.

SP and PA 80 Rubbers

Arising from technical service problems, a study was undertaken to compare the rate of breakdown of SP rubbers and the equivalent normal types of rubber prepared from the same bulk of latex. No appreciable difference in the rate of breakdown was observed, the initially slightly higher Mooney viscosity of the SP rubbers (four to five units) being maintained throughout a milling period of 30 minutes.

The effect of treating SP sheet with peptisers on the extrusion swell of a carbon black compound showed that at the same viscosity, rubbers containing peptisers gave values identical with the non-peptised material. The study included four commercial peptisers added on the internal mixer at 120°C and two peptisers added by open milling at 40°C.

It has been established that the compression set of compounds containing fillers is reduced with increasing amounts of PA 80 rubber up to a limiting filler content. In the case of inert fillers the improvement can be observed up to 50 volumes per hundred of rubber, using 12.5 parts of PA 80. With reinforcing fillers the improvement in compression set is found only up to 27.5 volumes of filler.

Some difficulty has been experienced by manufacturers in dispersing PA 80 rubber in stocks of low Mooney viscosity, particularly where preliminary breakdown of the PA 80 on the factory mill is not possible. Laboratory experiments have shown that the inclusion of 10 or 20 per cent of oil with the vulcanised latex during preparation resulted in softer PA 80 rubber, which was dispersed more readily, but even so could not be regarded as fully satisfactory. Work to improve the dispersibility of PA 80 rubber is being actively pursued. The use of oil-extended PA 80 gives stocks which extrude at lower rates than those obtained with normal PA 80, but gives extrudates with less sag. In a number of compounds examined the addition of 20 parts of oil to PA 80 has not led to appreciable changes in physical properties of the final vulcanisates. Further work studying the possibilities of applying these findings to commercial production is in hand.

As reported in *Annual Report 1960*, a new form of SP rubber, CA 50 has been produced which employs casein in place of vulcanised rubber particles to confer improved processing characteristics. Trials in a Malayan factory confirmed laboratory findings that CA 50 has an effect similar to PA 80 in conferring superior processing properties. Physical properties of vulcanisates prepared with CA 50 are not so good as those obtained with PA 80, but can be improved by the use of secondary accelerators of the aldehyde-amine type. Although it can be produced more cheaply than PA 80, CA 50 rubber is not yet regarded as suitable for commercial development and further information will be sought before taking a decision on this point.

NATURAL/SYNTHETIC RUBBER BLENDS

It is well known that *cis*-polybutadiene shows little or no breakdown with time when masticated on the mill. It has now been observed that when mixed with natural rubber it appears to reduce the rate of breakdown of the latter quite considerably. This was found to be particularly so when using skim rubbers, the

Mooney viscosity of blends after mastication being considerably higher than expected.

Physical properties of vulcanisates prepared with blends of equal parts natural rubber with oil-extended styrene-butadiene and with *cis*-polybutadiene (PB) rubber were found to be generally inferior to those of NR alone; blends with *cis*-polyisoprene (PI) did not differ much from NR compounds.

A series of natural rubbers specially prepared to retain more of the useful non-rubber constituents (HN rubbers) were found to give better properties than RSS when mixed with PI rubber, both in respect of gum stocks and carbon-black compounds. There was some evidence that HN rubbers gave improved tear resistance when mixed with Krylene NS, (cold SBR), the other properties remaining unchanged. The above findings are tentative and the work will be continued.

PROCESS EVALUATION AND FACTORY STUDIES

Economics of Sheet Manufacture

The nett direct costs in normal sheet manufacture, from reception at the factory through to baled rubber, are estimated to be about two cents a pound. An attempt has been made to analyse the contributions to the total cost made by the individual processes concerned, the breakdown arrived at being as follows:

Percentage Breakdown of Sheet Production Costs

Reception	2
Coagulation	28
Machining	8
Drying	29
Grading and baling	33
Total	100

The above analysis has been followed up by a programme of work aimed at reducing cost of sheet production, bearing in mind that current visual grading standards have to be met. The possibility of marketing rubber to a technical specification rather than on the basis of visual grading is another possibility which must be kept in view.

The work in hand to reduce cost of production of current types of rubber follows two main lines of study. The first is concerned with coagulation and machining methods, which used in conjunction with revised drying techniques, would allow coagulation at a higher d.r.c., or would give thinner sheet from coagulation at normal d.r.c. levels. The second line of work is aimed at an improved drying shed design, to give more economic drying of normal sheet and to permit the drying of sheet produced by novel methods of coagulation and machining.

Preliminary work using intensive machining suggests that besides decreasing sheet thickness it may be possible to reduce water content to a lower level than is normally achieved, thus shortening the time required for drying. Further work is required to confirm this and to weigh the extra costs in machining against the saving given by coagulating at higher d.r.c. and by reduced drying time.

Figure 4. Experimental Drying Tunnel at R.R.I.E.S., showing heat exchanger, re-circulation ducting and control gear on left-hand side.

The experimental oil-fired drying tunnel has now been constructed and was commissioned in October (*Figure 4*). This employs air circulation from a commercial oil-fired heat exchanger through a tunnel holding three trucks, each carrying 600 sheets. It is proposed to operate the tunnel on a two-stage drying system, employing different conditions of humidity and temperature for each stage. Trials have shown that certain adjustments are needed to provide the required control of the humidity of the circulated air and to give the desired distribution of air-flow.

Another aspect of the work on improved drying processes is the possibility of comminuting rubber so that a high surface area per unit volume is exposed and the time for the diffusion drying period reduced. A number of commercially available machines designed for cutting dry rubber, plastics and like materials have been examined for this purpose, both in Malaya and in the United Kingdom. So far none appear to be suitable for dealing with wet coagulum, which is slippery and results in a low rate of throughput. Further investigations are in hand.

New Double B Smokehouse

The new design of furnace for the R.R.I. Double B type smokehouse has been in operation at the Experiment Station for eighteen months. A slight bowing of the furnace sides up to one and a half inches from the original position has been observed. It is estimated that the life of the furnace arch will be six to eight years, which compares favourably with the two- to three-year average of the previous design.

The new design of smokehouse truck to take 1,200 pounds per trolley has fulfilled expectations and is giving satisfactory service. Experiments with various kinds of beroti designed to avoid contaminating the rubber with splinters has shown that the Y-section aluminium beroti is the only type available which satisfactorily overcomes this problem. Resins and thin sheet aluminium used as coatings for wooden beroties both failed after relatively short periods of service.

Recovery of Ammonia from Latex Skim

Studies on the recovery of ammonia from latex skim carried out during 1960 using a five-foot-long steam-stripping distillation column indicated that a satisfactory process could be worked out, but trouble was experienced with foaming which limited the throughput obtained. Early in 1961 it was decided to investigate other types of packing in the column and after consultation with experts in this field, it was decided to carry out pilot scale trials with a tray packing (known by the trade name of M.P.L./Leva Trays). Trials were arranged in Pittsburgh, U.S.A., using skim latex shipped from Malaya. Although the process still appeared promising it was again found that foaming limited the throughput. Various ways of overcoming this problem have been suggested, but to carry out further trials abroad would be costly and it has been decided to erect an experimental pilot plant at our Sungei Buloh factory, using a 12-inch diameter glass column and Leva trays. Meantime the requirements for recovering rubber from deammoniated skim have been studied. At present it appears that coagulation with one per cent sulphuric acid whilst the skim is still hot offers the greatest saving of acid and the best conditions for sharp coagulation.

Effluent Disposal

Further investigation using biological treatment on trickling filters for purification of effluent from rubber and latex factories has led to the interesting observation that much higher levels of pollution of the ingoing effluent appear to be tolerated under Malayan than under temperate conditions. Effluent with a very high biological oxygen demand, (over 8,000 p.p.m. B.O.D.) has been dealt with satisfactorily without 'ponding' of the bed, a condition which normally occurs under temperate conditions with highly polluted liquids owing to rapid proliferation of the micro-organisms forming the zoogleal film, thus blocking the interstices of the filter.

By feeding into the filter liquids having increasing levels of pollution, the proportion of oxidisable organic matter removed becomes less, but since the loading is greater, the amount of material dealt with and rendered innocuous increases; the most effective use of the filter thus appears to occur at high organic loadings. At present a number of runs on two filter beds connected in series is being carried out with a view to ascertaining the maximum organic load possible. Present indications are that for the first bed the maximum reduction in B.O.D. lies in the region of 150 to 190 lb B.O.D. per 1,000 cubic feet filter bed per day; this drops to 115 to 135 lb per day for the second bed, no doubt because it has to deal with liquors having lower organic loadings.

Speculative design studies for the purification of latex skim serum have been made, and attempts to arrive at a cost for the process. In considering a design for the treatment of 10,000 gallons per day of skim serum, a figure of 2.5 cents per pound of B.O.D. removed was derived. Allowing for 90 per cent reduction

in the degree of pollution of the effluent, (based on B.O.D.), this is equivalent to approximately 0.1 cent per pound of rubber processed to latex concentrate. It should be emphasised that this figure is based on insufficient data to be regarded as anything but highly tentative.

The disposal of factory effluent by degradation and running the relatively innocuous fluids to waste is by no means the preferred process and methods for usefully and profitably employing waste serum are being considered. The culture of yeast for cattle food production is mentioned elsewhere in this report (See Microbiology). Contact has also been established with another commercial concern interested in utilising skim serum, samples of which have been despatched for trials.

Comparison of Processes for Converting Latex to Dry Rubber

A simple experiment has been set up at Sungei Buloh in which dry rubber is prepared from a given bulk of latex by five different methods:

(1) Normal RSS, by coagulation at 15 per cent d.r.c.
(2) RSS, by coagulation at field d.r.c.
(3) Evaporation of latex to a total solids film, followed by overnight soaking in dilute acid to remove undesirable non-rubber substances (HN rubber).
(4) The flocculated rubber process, as described by M. Liponski.
(5) U.S.F. rubber, in which formaldehyde treated latex is flocculated with formic acid, heated, creped and dried.

This experiment will continue for one year, preparations being made once a month. The aim is to compare the different methods not only in respect of the properties of the rubbers they yield, but also in regard to the uniformity of the product throughout the seasons of the year. Duplicate preparations are carried out on alternate months to permit a more precise analysis of the data being obtained.

Experiments carried out with the Liponski flocculated rubber process, showed that deep bed drying of the flocs was not feasible owing to massing of the rubber. Drying in shallow layers was found preferable.

Carbon Black Masterbatch

Increasing amounts of styrene-butadiene rubber are being produced in America in the form of carbon black-rubber masterbatch with or without oil as an extender; at present the proportion of total SBR production sold in this form is said to be between 20 and 30 per cent.

Since manufacturers of rubber goods who use carbon black masterbatch do not require black mixing facilities in their factories, it is apparent that natural rubber is at a disadvantage in competing with synthetic rubber, unless it is available in a similar form.

An economic study of the possibilities for producing NR masterbatch in Malaya showed that owing to the extra costs involved in freight charges for transporting black to Malaya and thence to consuming countries in the form of masterbatch the effective cost of the black would be considerably increased. It is estimated that in the case of HAF black costing in the U.S.A. a little under 9 U.S. cents a pound as free black, the cost would be about 16 U.S. cents a pound when delivered in the U.S.A. as masterbatch. Since the advantage to the consumer is unlikely to

warrant the extra cost, commercial development of masterbatch production does not appear promising at the moment. The situation would presumably be modified should a carbon black factory be set up within the Federation, in which case a re-assessment of the situation should be undertaken.

Methyl Methacrylate Graft Rubbers

Until recently the small consumer demand in MG rubber has been fulfilled by a commercial concern in England, which prepared the graft from imported latex concentrate. The company decided early in 1961 to cease production and the R.R.I.M. undertook to manufacture the material at the Experiment Station factory on a temporary basis.

In order to maintain the supplies required it was necessary to scale up the small pilot plant production which had been used earlier for experimental purposes, and in so doing a number of improvements have been incorporated. For instance it has been found preferable to dilute high d.r.c. latices to 35 per cent, before reacting with the methyl methacrylate monomer, otherwise undue thickening of the mixture may occur, which renders control of the process more difficult. A new technique of coagulation has been developed which employs controlled injection of steam through a steam coil. Cheaper materials of construction for the plant have been found satisfactory, the reaction now being carried out in a mild steel vessel and coagulation in an aluminium tank. Cheaper sources of raw materials have also been found. The process is operated in batches, yielding 400 pounds of graft per batch. The revised process is now being costed and promises a reduction in selling price for MG rubbers in the near future.

Shipments during 1961 were as shown:

Period	Shipments, lb
1st quarter	210
2nd quarter	1,036
3rd quarter	3,684
4th quarter	5,648

The demand for MG rubber is still very small and does not at present merit production by commercial companies. Should the demand increase, however, a straightforward production process is now available for larger scale development. Attempts are being made to develop a suitable specification for MG rubbers so that uniformity of supplies can be ensured.

Production of Special Rubbers

The Experiment Station factory has continued to manufacture special rubbers, new materials being prepared for consumer evaluation and established types being produced only when market demands could not be fulfilled by commercial producers. The amounts produced and shipped during the year are recorded in *Table 39*.

TABLE 39. PRODUCTION AND SHIPMENT OF SPECIAL RUBBERS

Type	Amount produced, lb	Amount shipped, lb
SP brown crepe	86,727	85,120
PA 80 rubber	105,419	113,300
MG rubbers	16,514	10,578
Constant Mooney rubbers	1,500	1,500

ADVISORY AND TECHNICAL SERVICES

Chemical Division has continued to operate three types of advisory and testing services:

a. Chemical Division Advisory Service to Estates.
b. Technical Classification of Rubber.
c. Technical Service to Rubber Manufacturers.

Apart from the above, a considerable volume of routine testing work is carried out for other Divisions of the Institute, particularly by the Analytical Section, which devotes nearly 20 per cent of its time to this end.

CHEMICAL DIVISION ADVISORY SERVICE TO ESTATES

The production of rubber in Malaya increased from approximately 708,000 tons in 1960 to approximately 738,000 tons in 1961. This increase in production has been reflected in many enquiries received regarding designs for expanding factory capacity and for completely new factories, as well as other technical points concerning sheet and crepe production. Requests for advice on latex concentrate production were fewer than in 1960.

It should be recorded that close liaison is maintained between the Chemical Division Advisory Officers and Technical Service Officers working in Great Britain and the U.S.A. This permits consumer complaints to be traced back to their origins and is becoming an increasingly important factor in maintaining good quality in Malayan rubber production.

Sheet and Crepe Rubber Production

A considerable amount of time has been spent in drawing up factory plans to cope with increased crops. This work involves the consideration of many different aspects technical and otherwise, ranging from problems on siting to estate policy considerations. Subsequent visits during the commissioning period are also required. The advisory officers have been consulted by R.I.D.A. regarding smallholders' co-operative factories and have had discussions with representatives of F.L.D.A. and the R.R.I.M. Smallholders' Advisory Officer regarding latex collec-

tion and factory layout for processing latex in connection with the land development schemes which will shortly come into tapping.

Consideration has been given to reduction in costs of sheet manufacture, and it has been recommended that coagulation at as high a dry rubber content as possible should be aimed at, avoiding any marked increase in off-grade production. The use of coagulating tanks containing more partition plates is recommended for high d.r.c. coagulation, 90 partitions per tank being preferred to the usual 75. Attention to sheeting batteries is also called for, since some batteries are better suited to higher d.r.c. coagulum than others. The machining of continuous coagulum through a sheeting battery, followed by a cutting drum to give individual sheets, is considered to offer advantages in reducing costs. Cutting drums can operate effectively at an output of 3,000 pounds of dry rubber per hour.

Collection and transport of latex to the factory over long distances is a problem encountered by a number of estates. The use of formaldehyde, up to 0.07 per cent by weight on the latex, supplemented by addition of 0.05 per cent sodium sulphite or 0.03 per cent ammonia, has been found to be effective over relatively long distances of 50 miles and even more.

Problems with rust formation have been found to arise largely owing to the use of too low a temperature of drying in the smokehouse during the first and second day of drying. Dripping for periods in excess of six hours has also been found conducive to rust formation.

Bubbles in sheet remain the most common defect and most frequently arise because the pH of coagulation is too high. Improper adjustment of smokehouse ventilation and poor field hygiene also contribute to the occurrence of bubbles in sheet.

During the year more enquiries for rubber with low dirt content have been received. Co-operation with two estates has shown that dirt content can be maintained at acceptable low values throughout the year, average values for extraneous matter retained on an A.S.T.M. 325 mesh screen of 0.01 per cent to 0.015 per cent being achieved with little difficulty.

Mac and Lai improved additive used to produce a smoked sheet type of rubber by air drying has been further examined and the comments of users sought. No improvement in drying time compared with formic acid coagulation has been established.

A marked increase in the number of oil-fired driers in operation is again noted, some 200 units now being used for drying sheet and crepe rubber throughout the Federation.

Air-dried sheet production has increased during 1961. Trials on estates using oxalic acid to replace formic acid gave no improvement in colour. The use of Emulsion A concentrate, used for bleaching crepe rubber, was found to remove the yellow colour from sheet, but resulted in a dull unattractive appearance.

Interest in pale crepe production increased during the last half of the year, following more favourable conditions of sale. Enquiries concerning the use of Emulsion A Concentrate for bleaching were received, and trials were carried out on a number of estates to establish optimum conditions for its use.

Problems in ply adhesion arising in sole crepe production were dealt with by developing a new test procedure to measure this property, so that measurements could be obtained at half inch intervals across the whole width of the sheet. By

this means it was established that adequate adhesion of the plies at the edges of the sheet was an important factor and required special attention during the laminating process.

Packing of Rubber

Numerous complaints from consumers were received early in the year in regard to bale coatings which were of excessive weight and were not dispersible on milling the rubber, as required by the R.M.A. (New York) Conformance Tests set out in the Green Book. Investigation showed that bale coating powders had been mixed with resin as well as rubber, and thus failed to conform to specification. Co-operation with the M.R.E.R.B. and the S.C.C.R.A. has led to considerable publicity of the R.M.A. requirements in this respect.

Increased quantities of paper-wrapped RSS and pale crepe have been shipped during the year, mainly to the U.S.A. Complaints from consumers regarding the presence of talc and wood splinters in paper-packed rubber have been followed up and suitable recommendations made to producers.

Latex Concentrate

Production of latex concentrate fell during the first six months of the year, but increased during the second half giving a total production for the year of about 102,000 tons dry rubber content. Of this, nearly 10 per cent consisted of low ammonia types, production being more or less equally divided between the three main systems using, respectively, boric acid, zinc diethyldithiocarbamate and sodium pentachlorphenate as the secondary preservative.

The quality of Malayan produced concentrate has been maintained at a high level, and only a few problems arising from faulty procedures in field and factory have been encountered. Problems at present being studied in the laboratory include strainability of latex, the development of hydrogen sulphide in concentrate during bulk shipment, and the discovery that the wax lining of latex storage tanks may contain very high levels of bacteria.

Off-grade Crepes

A noteworthy development in the marketing of brown crepe grades is the recent interest shown in sales based on technical properties as opposed to simple visual grading. Requests have been received from remillers for assistance in meeting the requirements of customers that certain grades should show a given level of physical properties after vulcanisation.

Laboratory work has shown that brown crepe rubbers of different composition and different vulcanising characteristics are obtained depending on the source of the basic material used, i.e. tree lace, cup lump, precoagulum, etc. The properties of commercial brown crepe thus depend on the proportions of these constituents which have been blended during milling. Further modifications are introduced by the inclusion of bark, sand and soil, which varies with the degree of contamination of the scrap rubbers used and the care taken in milling. Investigations aimed at establishing optimum conditions for dealing with scrap are in hand.

Special Types of Rubber

Commercial shipments of special rubbers based on processes developed at the Institute are shown in *Table 40*.

TABLE 40. COMMERCIAL SHIPMENTS OF SPECIAL RUBBERS BASED ON R.R.I.M. PROCESSES, 1961

Type	Shipments in tons
SP RSS	1,794
SP pale crepe	227
SP ADS	168
SP brown crepe	573
PA 80	397
Partially purified crepe	170
Cyclised rubber	41
MG rubbers	5

The production of SP rubbers continues to expand, being 3,159 tons for 1961 as compared with 2,828 tons in 1960. Sixteen estates are at present making SP or PA 80 rubbers, but supplies were not always available to fulfill demands within the required time and the R.R.I.E.S. factory was called upon to manufacture 38 tons of SP brown crepe and 47 tons of PA 80, in order to meet consumer needs. This position is likely to continue until a larger market is established, since the demand shows wide fluctuations and producers are unwilling to maintain stocks large enough to meet the situation. SP rubber was shipped to 23 different countries during the year.

The R.R.I.M. continues to carry out quality control tests on all SP rubbers produced. The proportion of material rejected during 1961 was low, being 0.7 per cent of the total. Cleanliness of SP rubbers is very important, since much of it is used in high quality rubber goods. Producers have been advised to pay particular attention to this point since complaints of dirt and wood splinters have been received from manufacturers.

Commercial production of other types of special purpose rubbers was relatively small as will be seen from *Table 40*.

TABLE 41. ESTIMATED OUTPUT IN LONG TONS OF RUBBER FROM ESTATES USING R.R.I.M. FACILITIES FOR TECHNICAL TESTING*

Type	Technical Classification			
	Red Circle	Yellow Circle	Blue Circle	Total
Int. No. 1 RSS	301	20,972	4,522	25,795
ADS	425	5,864	199	6,488
Pale crepe	360	—	—	360
Brown crepe	—	400	7	407
Total	1,086	27,236	4,728	33,050

*including production from British North Borneo and from Socfin Co.

TECHNICALLY CLASSIFIED RUBBER

At the beginning of 1961, 72 estates were submitting samples for technical classification of their produce by the Institute. During the year, 9 estates withdrew from the TC Scheme and 16 joined, five of the latter requiring to classify only their production of brown crepe.

The total production of technically classified rubber in Malaya and North Borneo for 1961 is estimated at 33,050 tons, as compared with 30,490 tons produced during 1960. Most of this rubber came from estates, only 712 tons being classified from packing houses, which was, however, nearly double the 1960 figure of 381 tons. Details of estate production are presented in *Table 41.*

Four different packing houses requested classification of their produce, the amounts involved being shown in *Table 42.*

TABLE 42. RUBBER FROM PACKING HOUSES CLASSIFIED AT R.R.I.M., LONG TONS

Type	Technical Classification			
	Red Circle	Yellow Circle	Blue Circle	Total
Int. No. 1 RSS	—	156	31	187
" No. 3 "	—	30	305	335
" No. 4 "	—	—	5	5
Brown crepe	—	180	5	185
Total	—	366	346	712

The Division has continued to co-ordinate technical aspects of testing stations situated in Malaya and other producing territories, under the auspices of the International Rubber Research and Development Board. *Technical Bulletin No. 40* was issued in July, reporting on world production for 1960, which totalled 45,268 tons, being 0.3 per cent lower than the corresponding figure for 1959.

Inter-laboratory cross-checks involving nine stations in five countries were held in October; the data received are now being analysed.

Lists of estates supplying *bona fide* TC rubber are now prepared quarterly, and are published in Natural Rubber News as well as being distributed to N.R.B. Technical Service Officers.

The maintenance of estate production at a constant level, as judged by the strain test used for technical classification, is affected by many factors, including young rubber trees coming into bearing, high intensity tapping systems and trends in processing procedure, such as coagulation at higher dry rubber content. During the year these factors led to a higher proportion of rubbers being classified as blue circle. Although this problem has been satisfactorily overcome by the use of formalin in most cases, anomalous behaviour has sometimes been encountered. The irregularities are thought to be associated with the use of certain anticoagulants and are being followed up.

Technical classification is based on the American Chemical Society's No. 1 formulation for compounding rubber, which employs 2-mercaptobenzothiazole, (MBT), as the accelerator of vulcanisation. Requests for information on the applicability of the classification to other types of vulcanising systems led to an experiment comparing the properties of red, yellow and blue rubbers when cured with other accelerators. It has been shown that the order of ranking given by the classification scheme holds good in respect of di-2-benzothiazyl disulphide (MBTS), tetramethyl thiuram disulphide (TMTD), N-cyclohexyl-2-benzothiazole sulphenamide, (CBS), and zinc diethyl-dithiocarbamate, (ZDC), but not for N.N′-diphenyl guanidine, (DPG) and butyraldehyde/aniline condensation product, BA. Discrimination between the three classes of the TC Scheme was most pronounced in the case of MBT and MBTS, and least for CBS and TMTD.

Interest in TC rubber is still largely confined to consumers in the smaller factories. A demand for TC brown crepe was noted towards the end of the year, although the tonnage marked was only just over one per cent of the total TC rubber shipped. It is interesting to record that technological tests, carried out on 2,000 tons of the same grade of brown crepes from seven different remilling factories, showed an unexpected uniformity of vulcanising characteristics from all sources, although dirt, manganese and copper contents were not so uniform.

TECHNICAL SERVICE TO RUBBER MANUFACTURERS

Technical Service activities have been extended, following an increased number of requests for assistance from manufacturers, the total amounting to 199, as compared with 78 during the preceding year. *Table 43* records the enquiries received:

TABLE 43. TECHNICAL SERVICE ENQUIRIES, 1961

Origin	Total number of enquiries	Enquiries involving laboratory work
Federation and Singapore	104	61
India	86	6
Other Countries	9	3

Enquiries from Malayan manufacturers increased during 1961 and a large increase in requests from India followed the opening of the N.R.B. Office in Bombay early in the year. Most of the advice sought concerned the manufacture of tyres, tubes, footwear and soleing, although quite a number of requests for help were received on raw materials, mechanical goods and bonding problems.

The rubber technologist spent two months on a technical service tour in the Scandinavian countries and North Germany, visiting rubber manufacturers in company with a member of N.R.P.R.A. staff.

Liaison

Active liaison has been maintained with N.R.P.R.A. Technical Service Officers in England, and N.R.B. staff in America, Malaya, Australia, New Zealand and South Africa.

The Division has continued to act as convenor for the Committee of Malayan Latex Technologists reporting its views to the British Standards Institution, Sub-Committee RUC/10/7. Contact has been maintained with the International Standards Organisation and with Sub-Committees of the American Society for Testing Materials Committee D-11. Assistance has been given to the Rubber Manufacturers' Association of New York leading to modifications in the Green Book of Rubber Type Descriptions. Liaison has been maintained with sister Research Institutes in other territories and with the International Rubber Research and Development Board.

W. G. Wren
Head of Chemical Division

Statistics Division

The Statistics Division exists primarily to assist research officers in the design and analysis of experiments and also to provide data-processing facilities. In addition, some preliminary work-study investigations and studies of costs of production were started towards the end of the year.

DATA PROCESSING

The volume of data from field and laboratory experiments continued to increase. During the year, the punched-card installation summarised over sixty sets of tree-by-tree data from manuring and clone trials, involving over 200,000 cards.

Statistical assistance was given to the Smallholders' Advisory Service on the planning of three sample surveys. These concerned a survey of smallholdings replanted in Negri Sembilan in 1954, a survey of R.I.(R.)B. grant-deferred holdings in Kelantan and Trengganu 1956-60, and a study of brown-bast incidence on 1600 smallholdings. The processing of these survey data on the punched-card equipment was almost completed by the end of the year.

Hitherto, when analysing field experiments, the punched-card equipment has been used solely for preparing plot summaries while statistical computation of plot data was confined to desk calculators. However, the use of the punched-card equipment in analysis of variance has been examined, and work on data from a multi-variable $3^2 \times 2^4$ factorial experiment showed that part of the computation in such cases can be done more rapidly by punched cards than by desk calculator.

STATISTICAL ANALYSIS

The main work of the Division during the year has been the statistical analysis and interpretation of data from experiments. Over two hundred reports were made to the various Divisions embodying the results of such analyses.

Most of the statistical analyses for Soils Division were concerned with studies of contents of leaf samples and soil samples in manuring and cover crop experiments. Similarly, the bulk of the work for Chemical Division concerned the mineral content of latex from various manuring experiments. A scheme for sampling rubber bales in large commercial packing houses was devised. Work for Botanical Division dealt mainly with the results of clone trials.

WORK-STUDY INVESTIGATIONS

Some preliminary work-study investigations and studies of costs of production were started at the end of the year.

A study of production costs of ninety-seven companies each owning more than 500 mature acres showed a marked relation between costs per pound and yield per acre, averaging $1\frac{1}{2}$ cents reduction for each increase of 100 lb. However, yield per acre accounted for only a small fraction of the total variation in costs per pound and there were large cost differences among companies having the same mean yield per mature acre.

A breakdown of production costs on a sample of estates demonstrated that direct costs of tapping and collection accounted for over half of the ex-estate costs (i.e., excluding export duty, cesses, and replanting provision). Observations on the time required for tappers to complete their tasks under varying conditions emphasised that only a small part of the full working day was occupied in skilled operations.

A method study of the operations of tapping, collection of latex and of scrap, and their transport to the factory was started in an attempt to establish the most efficient methods appropriate to different conditions.

A. FONG CHU CHAI
Acting Head of Statistics Division

Smallholders' Advisory Service Division

Smallholders in the Federation of Malaya account for approximately 42% of the total rubber production of the country and some 14% of world production. Accurate data on the smallholding industry are not available but it is estimated that approximately 280,000 smallholders own a total of 2,000,000 acres of rubber land, the typical holding being approximately 5.6 acres in size. But holdings often comprise two or more parcels of land, separated geographically although belonging to a single owner. It is estimated that some 462,000 separate parcels make up the total smallholding acreage, which is distributed through all States in the Federation.

The task of the Smallholders' Advisory Service is to provide technical information and advice on rubber growing and processing for this very large smallholders' section of the Malayan Rubber Industry. To do this, a staff of trained advisory officers is posted in all rubber growing districts. Their work is at present directed by seven Senior Officers stationed in Kuala Lumpur but it is intended that some of these officers should shortly be posted to stations elsewhere to provide closer supervision in the field and better liaison with State and District authorities.

Rural development was the theme of 1961 in Malaya. Official interest in the development of rubber smallholdings has been increasing over the past few years and during 1961 major efforts were directed towards increased smallholders' new planting and replanting and to the improvement of the smallholders' product. In all these aspects of rubber smallholding development, the Smallholders' Advisory Service played a part, limited perhaps by the lack of experienced staff, but none the less substantial. That this was possible was due to the policy of expansion followed by the Service in recent years and more particularly since 1959. Details of work undertaken and results achieved during 1961 are provided in later sections of this report but the increasing scope of the Service can best be illustrated by the increases in staff which have taken place: the total number of staff has more than doubled during the three years 1959 – 61, but there has been increasing reliance on Assistant Rubber Instructors, with little increase in more senior staff.

Training of Staff

Only those holding the Diploma of the College of Agriculture, Serdang, are considered for appointment as Rubber Instructors and as facilities at the College have been limited, the Board has granted scholarships to prospective Rubber Instructors each year since 1951. During 1961 only six places for R.R.I.M. Scholars could be obtained at the College and this number of scholarships was therefore awarded to bring the total of prospective Rubber Instructors at the College to 21. Five scholars will complete their course in 1962, ten in 1963 and six in 1964.

Assistant Rubber Instructors receive three months' initial training during a course conducted at the R.R.I.M. Experiment Station by senior S.H.A.S. officers. Two such courses were attended by sixty-four prospective Assistant Rubber Instructors and twenty students sponsored by other organisations.

Two Refresher Courses, each of eight days' duration and held at the R.R.I.M. Experiment Station, were attended by a total of thirty-seven serving Assistant

Rubber Instructors. The courses covered recent technical advances but were primarily concerned with the application of extension methods and definite results have been noticed in the form of better planned work by the Assistant Rubber Instructors who attended. More courses of this type are necessary for the increasing numbers of staff having little experience and it is hoped that it will be possible to increase the number of refresher courses during future years.

One recently appointed Rubber Instructor attended an Outward Bound Course during the latter part of the year. A very useful report resulted and it is hoped that more Rubber Instructors and Assistant Rubber Instructors will later have similar opportunities.

ADVISORY

The estimated acreage of smallholders' rubber in the Federation and its distribution by States is shown in *Table 44*. This estimation is based on the acreages reported by the Department of Statistics as planted on smallholdings in 1952. Being based only on Land Office records, these figures may be subject to considerable error but are nevertheless the best estimate available. To these acreages are added figures for new planting, which are considered reasonably accurate and also an estimate for the area of new smallholdings resulting from the fragmentation of estates. This latter figure is by no means reliable but is obtained by distributing the total area fragmented from estates proportionately to the total estate acreage in each

TABLE 44. ESTIMATED DISTRIBUTION OF SMALLHOLDERS' ACREAGE, DECEMBER 1961

State	1952 acreage	Additions 1952—1961			Total 1961
		Fragmentation from estates	Block new plantings	Individual new plantings	
	Acres	Acres	Acres	Acres	Acres
Johore	541,240	61,887	40,226	12,883	656,236
Kedah/Perlis	146,278	23,381	6,721	13,128	189,508
Kelantan	65,108	4,836	13,187	11,113	94,244
Malacca	87,144	12,818	8,754	1,401	110,117
Negri Sembilan	128,211	30,300	12,125	6,046	176,682
Pahang	98,453	13,079	23,285	21,485	156,302
Penang/Province Wellesley	29,030	3,101	—	65	32,196
Perak	310,119	29,259	7,696	11,530	358,604
Selangor	163,731	36,287	2,889	412	203,319
Trengganu	46,779	1,952	4,867	5,538	59,136
Total	1,616,093	216,900	119,750	83,601	2,036,344

State. This distribution is purely arbitrary and is used only in the absence of more reliable data.

Neither the total acreage nor its distribution can be accepted as accurate but the estimates made are the best possible from the data available and are sufficiently accurate to provide a useful working guide.

The work of the Smallholders' Advisory Service is carried out by field officers giving advice to individual smallholders largely by word of mouth. It is reasonable, therefore, to expect that the advisory staff should be distributed through the country in roughly the same manner as the smallholders' plantings. *Table 45* shows the distribution of smallholders' rubber acreage in comparison with the distribution of S.H.A.S. field staff and the visits made by these officers.

TABLE 45. DISTRIBUTION OF SMALLHOLDERS' RUBBER COMPARED WITH DISTRIBUTION OF ADVISORY STAFF, DECEMBER 1961

State	Distribution of smallholders' acreage	Distribution of S.H.A.S. field staff	Distribution of advisory visits
	%	%	%
Johore	32.22	21.25	25.45
Kedah/Perlis/Penang/ Province Wellesley	10.88	10.62	10.68
Kelantan	4.63	7.5	6.67
Malacca	5.41	5.0	5.05
Negri Sembilan	8.68	11.25	15.84
Pahang	7.67	13.12	10.07
Perak	17.61	18.12	14.39
Selangor	9.98	9.37	8.51
Trengganu	2.92	3.75	3.33
Total	100.00	99.98	99.99

In general, the distribution of staff is in keeping with the distribution of smallholders' acreage except in Johore where staff is markedly lower than would be expected and in Negri Sembilan, Kelantan and Pahang, where staffing is comparatively higher. In Johore, more staff is certainly required and will be provided during 1962 as recruits are trained and adequate supervisory staff becomes available. The excess of staff in Kelantan, Pahang and Negri Sembilan is, however, apparent rather than real. In the first two States, communications are difficult and each man can therefore cover only a small area efficiently. In Negri Sembilan, advisory work is perhaps better organised than elsewhere and a comparatively larger field staff has been necessary to maintain the intensity of advisory work. As new postings are made to other States, the percentage distribution of staff will come into line with the distribution of smallholders' acreage and the present variations are in fact an indication of the variations in current development activity in each State.

Advisory work has continued to be divided between work with groups of smallholders in training courses, demonstrations, discussion groups and lectures, and work with individual smallholders during visits to holdings when specific problems are discussed. The time spent by staff in each of these advisory approaches is not known, but it is estimated that they have spent approximately one-third of their time in group activities and two-thirds in individual visits.

The pattern of individual visits made by field staff in each State is shown in *Table 46*.

It can be seen that work with immature holdings, both new plantings and replantings, has continued as the major part of the advisory effort, visits to mature holdings accounting for only 16% of the total. These latter visits will have been largely to recently matured plantings, where advice on tapping is important, rather than to holdings planted with old seedling rubber with which little effective advisory work can be done. Individual replantings were the most frequently visited holdings and accounted for the greatest proportion of both first visits and subsequent visits. This is to be expected as these holdings were operated by individuals needing technical advice to enable them to comply with the requirements of the Replanting Scheme. New plantings, on the other hand, were mainly grouped in block development schemes, each of which provided some measure of control over planting practices. Less effort was therefore required in advisory work to individuals owning new plantings in the schemes, although advice to the schemes as units continued to be an important part of our work.

The number of visits by Rubber Instructors and Assistant Rubber Instructors are combined in the table but a breakdown shows that Rubber Instructors made 9,452 visits and Assistant Rubber Instructors 64,829 visits, the pattern being the same as regards the type of holding visited but with Rubber Instructors making rather more first visits and averaging less visits per head. The inference is that Rubber Instructors are exercising their correct function in dealing with problems in the initial stages and then leaving repetitive work on the ground to the Assistant Rubber Instructors whom they supervise.

Planting of Rubber

The acreage of new planting carried out by smallholders during 1961 is shown in *Table 47*. While the area of new plantings by individuals increased considerably, by far the greatest amount was done by participants in Block Schemes. Planting under Federal Land Development Authority Schemes and State Land Development Schemes continued, the F.L.D.A. initiating 9 new schemes and the various State Land Development Boards 15 schemes during 1961. These schemes together provide for the planting of 34,722 acres of rubber divided into smallholdings of 6 acres each, but development is planned in phases and only the acreages actually planted during the year are shown in *Table 47*.

Fringe Alienation Schemes provide blocks of new land, sub-divided into small areas for alienation to existing owners of smallholdings of an uneconomic size. The blocks of land are selected as close to the existing holdings as possible and normally comprise irregular areas on the fringe of existing settlements. Successful applicants for land in these areas are allocated between 2 and 6 acres each, according to the size of their existing holdings. The block area is felled, cleared and (where necessary) terraced by contractors, after which the settlers themselves are

TABLE 46. VISITS TO SMALLHOLDINGS BY FIELD STAFF, 1961

State	Mature rubber				Replanting				New planting				All plantings	
	First visits	Subsequent visits	Sub-total all visits	% of all State visits	First visits	Subsequent visits	Sub-total all visits	% of all State visits	First visits	Subsequent visits	Sub-total all visits	% of all State visits	Total visits	% of all Federation visits
Johore	2,081	1,009	3,090	16.3	4,921	3,049	7,970	42.2	4,556	3,289	7,845	41.5	18,905	25.5
Kedah/Perlis/Penang/P. Wellesley	591	713	1,304	16.4	1,733	2,065	3,798	47.9	981	1,847	2,828	35.7	7,930	10.7
Kelantan	344	56	400	8.1	1.524	132	1,656	33.4	2,637	263	2,900	58.5	4,956	6.7
Malacca	1,002	258	1,260	33.6	1,594	352	1,946	51.9	442	101	543	14.5	3,749	5.0
Negri Sembilan	971	456	1.417	12.0	2,615	2,416	5,031	42.7	2,328	2,992	5,320	45.3	11,768	15.8
Pahang	979	157	1,136	15.2	1,716	598	2,314	30.9	2,650	1,381	4,031	53.9	7,481	10.1
Perak	1,149	506	1,655	15.5	4,269	2,854	7,123	66.6	1,024	890	1,914	17.9	10,692	14.4
Selangor	1,177	742	1,919	30.3	2,235	1,229	3,464	54.8	427	513	940	14.9	6,323	8.5
Trengganu	111	4	115	4.6	247	23	770	31.1	1,353	239	1,592	64.3	2,477	3.3
Total	8,405	3,891	12,296	—	21,354	12,718	34,072	—	16,398	11,515	27,913	—	74,281	100.0
Totals expressed as percentages of totals for all types of planting	18	14	16		46	45	46		36	41	38		100	

TABLE 47. NEW PLANTING BY SMALLHOLDERS, 1961, IN ACRES

State	Federal Land Development Authority Schemes	State Land Development Schemes	Fringe Alienation areas	Other subsidised areas	Unsubsidised block plantings	Unsubsidised individual plantings	Total
Johore	4,766	1,000	—	76	11,695	6,263	23,800
Malacca	834	—	1,496	—	559	114	3,003
Negri Sembilan	2,196	550	643	—	2,747	—	6,136
Selangor	850	890	—	75	—	25	1,840
Perak	931	4,068	—	—	36	429	5,464
Kedah/Perlis	1,894	702	18	—	—	1,305	3,919
Kelantan	—	1,844	—	3,269	—	427	5,540
Trengganu	800	663	—	—	—	1,219	2,682
Pahang	2,674	1,340	2,436	99	5,052	3,451	15,052
Total	14,945	11,057	4,593	3,519	20,089	13,233	67,436

responsible for all work on the holdings. Planting materials and a certain amount of fertiliser are provided without charge to bring the total value of grant assistance to $200/- per acre. In some States additional financial assistance is provided from State Government funds in the form of a loan repayable after the holdings come into production. Thirty-seven Fringe Alienation Schemes were implemented during the year to provide for a total of 19,242 acres of new rubber.

The Other Subsidised Areas listed in *Table 47* comprise New Village plantings in Kelantan, block new plantings receiving a grant from the Rubber Industry (Replanting) Board, Fund "B" and the last remaining planting on areas alienated for the re-settlement of ex-Special Constables. These projects together provide for the planting of some 11,400 acres of new rubber but development, again, is phased.

Unsubsidised Block Plantings are distinguished from individual new plantings as information on the block areas is more accurate. No assistance or control is provided in these areas, numbers of smallholdings of varying size being alienated in blocks only for convenience in avoiding scattered small areas of individual development.

Advice to New Planting Schemes

Advice to new planting schemes occupied approximately 40% of the total advisory effort. One Senior Officer devoted his full time to this work and made sixty-five visits to different block schemes during the year. In many cases, these visits resulted in the provision of a detailed planting and maintenance programme as a guide for the authorities responsible. Later advice, on implementation of the basic programme, was provided by Rubber Instructors both at committee meetings and in the field and by Assistant Rubber Instructors in the field. In almost all schemes, advice on planting material was offered and, in many, detailed advice on such items as soil conservation, weed control and planting techniques.

Provision of advice and instruction in practical techniques for the very large numbers of settlers involved necessitated the introduction of special training courses on Federal Land Development Authority Schemes and on certain Fringe Alienation Schemes. On F.L.D.A. Schemes continuous courses, occupying approximately 3½ hours each day over a period of 14 days, were provided at seven schemes where nineteen courses attended by 488 students were completed. The first to attend these courses were settlers' group leaders but when training of these key men was complete, courses were offered for all settlers. The courses, therefore, occupied a great deal of the time of Assistant Rubber Instructors but were considered justified as initial complete training for all participants in new planting schemes was expected to lead to willing acceptance of later and more detailed advice.

Similar, but shorter, demonstration courses were provided for participants, in Fringe Alienation Schemes in Negri Sembilan. The courses were divided into two parts, the first covering the planting of rubber, cover crops and the essentials of weed control, and the second covering maintenance, manuring and budgrafting. Each part occupied three morning sessions of talks and practical demonstrations. The first part of each course was given as soon as settlers could be gathered, either on their new holdings or in settlements nearby, and the second parts will be given after the new holdings are planted. This division of the courses was made because of the need to teach the elements of rubber planting to large numbers of settlers

during a very short period. In Negri Sembilan, Assistant Rubber Instructors completed the first parts of thirty-six courses attended by 1,101 settlers on fourteen separate Fringe Alienation Areas. Attendance at courses was not compulsory but in each case the District Officer responsible for the scheme notified settlers of courses and encouraged their attendance. This backing was of real assistance and each course was, in fact, attended by thirty to forty settlers: the maximum number which a single instructor could handle. As a result of the introductory courses most of the Fringe Alienation Areas in Negri Sembilan have been well planted, with rubber correctly spaced in well prepared planting holes and with cover crops correctly planted in the inter-rows. In Negri Sembilan also, a special fourteen-day course of instruction on planting materials, planting and maintenance techniques was provided for twenty-four of the Field Assistants supervising Fringe Alienation Areas.

The above courses gave complete instruction on land preparation, planting and maintenance, the provision of advice being organised in collaboration with the authority responsible for the scheme so that the minimum of any Instructor's time was required. Similar advice was provided to individual new planters but by means of separate visits, as it was not possible to organise these smallholders into groups suitable for the provision of a set course. Many new planters, however, attended other courses provided at kampong centres and so obtained the basic information they required without individual visits from Instructors.

The Smallholders' Advisory Officer continued as a member of the Federal Land Development Authority and attended a number of meetings of the Authority and its sub-committees. Mr Wong Mun Yun also attended a number of Land Development Board and other meetings in connection with new planting schemes in different States. Participation in such meetings has made it possible for advisory work to be planned from the inception of the Schemes concerned, to the advantage of both advisory workers and settlers.

Planting Materials Used on New Plantings

All new planting schemes, with the exception of certain small and inaccessible areas, were planted with ordinary seed for later field budgrafting. Of scheme areas planted during 1961 only 2,622 acres or 7.5% were planted with clonal seedling material. The same trend towards budgrafting is shown in the unsubsidised block plantings and individual new plantings, the first having 6% clonal seedling material and the second 28%. All other unsubsidised plantings were with ordinary seed most of which will be budgrafted in due course. On previously established individual new plantings 10,436 acres were budgrafted during 1961. This is a continued indication that all new plantings reported by Rubber Instructors as planted initially with ordinary seed are eventually budgrafted. A record of the budwood used in budgrafting 9,034 acres of new planting has been kept by Rubber Instructors whose reports are summarised in *Table 48*.

While the older, well proven but less high yielding clones remain the most widely used material, comparison with the clones used during 1960 shows an increasing use of the newer clones. While these are now available from official nurseries the supply of budwood of such clones as RRIM 605 and 623 cannot meet the demand and this fact almost certainly restricted use of these clones. As more recently

TABLE 48. BUDWOOD USED ON INDIVIDUAL NEW PLANTINGS, 1961

Clone	Yards used	Acres budded	Area as % total acres budded	
			1961	1960
Tjir 1	29,643	1,586	17.5	29.5
PB 86	47,370	2,534	28.0	41.6
PR 107	18,306	961	10.6	7.6
RRIM 501	4,224	216	2.4	6.8
RRIM 513	13,972	744	8.2	2.0
RRIM 605	6,436	378	4.2	0.7
RRIM 623	3,027	208	2.3	1.1
Other new clones	1,465	84	1.0	1.0
Mixed clones	41,259	2,323	25.7	9.7
Total	165,702	9,034	99.9	100.0

established nurseries come into production an increasing use by smallholders of the most modern material is expected.

Supply of Budwood from the R.R.I.M. Experiment Station to Smallholders

The sale of budwood of the newer clones to smallholders from the R.R.I.M. Experiment Station continued, a total of 4,587 yards being supplied. This budwood was supplied only in small quantity to each individual—for multiplication and later use on a replanting or new planting. Distribution of 4,587 yards therefore presages a large area of field budding with the clones supplied. Budwood of RRIM 701 and 707 was supplied to smallholders only after each applicant had been warned of the possible danger in using these unproven clones, a letter being sent from headquarters and a visit being made by a Rubber Instructor or Assistant Rubber Instructor. Smallholders who budded these clones in nurseries were therefore fully aware of the nature of the material but nevertheless demand was considerable. The most used clones were RRIM 605 and 623 which together accounted for 74.3% of the budwood supplied. These clones, being vigorous and high yielding, are considered well suited to smallholders' needs and their use will be encouraged.

Advice to Replantings

Advisory visits to replanting schemes accounted for 46% of all visits made by field staff and instruction on replanting methods formed a major part of all training courses. Most frequently advice was sought on lalang eradication, disease control and planting materials. In addition, nearly all replanted holdings receiving the final instalment of the Replanting Grant were visited by field staff. These visits were to advise on maintenance of the holdings and as a preliminary to provision of detailed advice on tapping and processing.

No data on replantings was collected as accurate information is published by the Rubber Industry (Replanting) Board, with which organisation the Service continued to collaborate at all levels.

Processing of Smallholders' Rubber

The main advisory effort in this field was directed to the establishment of Group Processing Centres but work with small central factories and the improvement of processing by individuals was not neglected. A Group Processing Centre provides simple equipment, and often a smokehouse, for use by smallholders who process their own latex at the centre and, after smoking, sell it either individually or in groups. Where group sales are arranged Co-operative Marketing Societies are sometimes formed.

During 1961, fifty-six new Group Processing Centres were established as a direct result of advisory work and details of the present position are shown in *Table 49*.

TABLE 49. GROUP PROCESSING CENTRES ESTABLISHED ON S.H.A.S. ADVICE 1959-1961

State	Number of centres			Number of centres with a smokehouse	Number of users	Monthly throughput, pikuls	Centres under construction
	Established 1959/60	Established 1961	Total operating				
Johore	8	13	21	3	419	876	—
Kedah/Perlis	5	5	10	1	149	169	1
Kelantan	6	12	18	3	375	323	2
Malacca	5	1	6	5	97	77	—
N. Sembilan	3	3	6	3	76	84	—
Pahang	8	5	13	10	251	376	—
Perak	14	3	17	2	239	330	1
Selangor	10	8	18	18	460	626	1
Trengganu	2	6	8	4	260	216	—
Total	61	56	117	49	2,236	3,077*	5

*Rate of production was 2,198 tons per year.

The number of group processing centres was very nearly doubled during the year and the rate of production raised to 2,198 tons per year. At twenty-one of the centres bulk sales of the smallholders' sheet was arranged and bulk processing was introduced at three new centres to bring the total processing in bulk to five.

Bulk processing can be regarded as the next step forward from group processing centres towards large central factories of a size sufficient to justify mechanisation and a paid manager. The difficulty of assembling a large quantity of latex from a large number of scattered smallholders, each producing only a few gallons, makes the economics of large factories doubtful. But this problem does not arise in the

smaller units where smallholders themselves carry their latex to the factory where it is processed in bulk by paid labour and after smoking, sold in bulk. Small central factories can therefore be encouraged, where smallholders prefer to use for other purposes the time normally spent in sheet making, and advantages of more efficient production of a uniform bulk of good quality sheet can be expected to provide an improved return to the producer. The same is not necessarily true of larger factories where the cost of latex collection often results in no improvement in the return to the producer, despite efficient factory operation. This problem requires further investigation but for the time being group processing centres and small central factories developed from them can be confidently recommended to smallholders.

In addition to the group processing centres established as a result of advisory work, a similar number of privately established group processing centres continued to operate, together with other central factories and organisations collecting smallholders' latex for processing into concentrate. The complete picture of organised processing of smallholders' latex, as reported by field staff, is shown in *Table 50*.

TABLE 50. MONTHLY PRODUCTION OF ORGANISATIONS FOR PROCESSING SMALLHOLDERS LATEX, 1961, IN PICULS d.r.c.

State	Producing sheet rubber				Collections of latex for concentration
	Group processing centres		Central factories		
	Established on S.H.A.S. advice	Proprietary centres	Co-operative	Proprietary	
Johore	876	313	—	2,217	1,290
Kedah/Perlis	169	—	—	—	1,011
Kelantan	323	—	—	—	—
Malacca	77	—	—	—	—
N. Sembilan	84	1,163	—	—	145
Pahang	376	44	—	—	—
Perak	330	86	56	716	—
Selangor	626	6,616	180	744	495
Trengganu	216	18	—	—	—
Total pikuls per month	3,077	8,240	236	3,677	2,941
Equivalent total: tons per year	2,198	5,886	168	2,626	2,100

These central organisations, producing a high quality product, are now processing smallholders' rubber at the rate of 12,979 tons per year. This represents only a little over 4% of the total annual production attributed to smallholders but is nevertheless of importance as it shows a sure improvement in quality of the rubber produced by some 8,000 smallholders.

INFORMATION AND EDUCATION

The R.R.I.M. Smallholders' School at Ayer Pa'abas, Malacca, has been in operation since 1957, providing one-month residential courses for smallholders continuously during all suitable months of the year. The demand for such training continues to be great and it has never been possible to accommodate all applicants at Ayer Pa'abas. While training courses are provided at many kampong centres with very satisfactory results, conditions in the kampong are rarely ideal and facilities for practical work are often difficult to provide. Provision for a second Smallholders' School was therefore approved by the Board. A 32-acre rubber holding was purchased near Padang Rengas in Perak and building of the new school, which will accommodate between 30 and 40 students, was commenced during September. The school is expected to be completed early next year.

Training courses at three levels of instruction have continued throughout 1961, all three types of course being provided at kampong centres and 'Standard Courses' at the Ayer Pa'abas Smallholders' School. Details are shown in *Table 51.*

TABLE 51. TRAINING COURSES FOR SMALLHOLDERS, 1961

Type of course	Number of courses	Students enrolled	Students completing courses		Examination passes and certificates awarded	
			Number	Percentage	Number	Percentage
Extension Courses:						
Chinese	2	67	46	68.6	40	86.9
Standard Courses:						
Ayer Pa'abas, Malay	6	141	141	100.0	127	90.1
Ayer Pa'abas, Chinese	2	50	50	100.0	48	96.0
Kampong Centres, Malay	8	210	157	74.8	126	80.2
Kampong Centres, Chinese	3	91	78	85.7	60	76.9
Practical Courses:						
Kampong Centres, Malay	71	1,895	1,326	70.0	1,212	91.4
Kampong Centres, Chinese	17	450	299	66.4	272	91.0
Total	109	2,904	2,097		1,885	
Average				72.2		89.9

A total of 2,097 students completed courses, almost double the number of students completing courses during 1960. This is an indication of the importance attached to training courses which are regarded as the foundation on which later and more specialised advisory work can be built up. Every Assistant Rubber Instructor with more than one year's experience in the field is encouraged to organise Practical Courses, each occupying one day each week over a period of

six or seven months and to have a course in progress at all times; it is intended that a still greater number of courses shall be provided during 1962. There were forty-three courses of different types, attended by 1,174 students, in progress at the end of 1961.

Visits by Students to the Institute and Experiment Station

Forty-one groups of smallholders who had completed training courses, joined in some cases by other smallholders, arranged for themselves visits to the Institute and Experiment Station. In this way 1,179 smallholders were able to see research work in progress, both in the laboratory and in the field, and so round off their knowledge of rubber.

Training Courses for Other Organisations

A special course for twenty-six second-year students of the College of Agriculture, Serdang, was provided at the R.R.I.M. Experiment Station between 9 and 18 January. Lectures were given not only by S.H.A.S. Officers but also by officers of other Divisions.

At courses provided primarily for the training of prospective Assistant Rubber Instructors, nominees of other organisations were accepted; eight from the Federal Land Development Authority, one from the Rubber Industry (Replanting) Board, three from the Department of Agriculture, Sarawak, two from the Department of Agriculture, North Borneo, two from the Ministry of Education and two from the University of Malaya. In addition two private students attended making a total of twenty students other than prospective S.H.A.S. employees.

Ten Field Assistants of the Federal Land Development Authority, attended courses at Ayer Pa'abas, following the normal syllabus of the school.

Lectures by Rubber Instructors or Assistant Rubber Instructors during courses provided by the Department of Agriculture at Rural Training Centres continued. A total of 106 such courses in all States included talks or demonstrations by S.H.A.S. staff, the time allocated to rubber subjects varying between 2 hours and 7 days at different centres. In no case, however, could the instruction on rubber be considered complete nor comparable to that provided by R.R.I.M. Courses.

Mobile Demonstration and Film Units

The four Land Rovers fitted as demonstration and film units were in operation throughout the year as shown in *Table 52*. In addition, the Land Rover supplied to the Senior Rubber Instructor at Machang, Kelantan, was equipped as a demonstration unit and gave a number of sheet making demonstrations at kampongs in Kelantan and Trengganu.

At processing demonstrations nearly 10,000 rubber sheets were prepared and it is estimated that over 12,000 smallholders took part.

The units were used in connection with training courses, both to show instructional films and to provide equipment for a practical test on sheet making at the end of each course. They were used also at Agricultural Shows, in different parts of the country.

The six instructional films shown by the units were made in 1951. While much of the technical information remains correct, changes are required and also films of more topical interest. A start was therefore made towards the end of the year

TABLE 52. USE OF MOBILE UNITS, 1961

State	Processing demonstrations	Film shows
Johore	90	72
Kedah / Perlis	22	30
Kelantan	13	21
Malacca	20	20
Negri Sembilan	11	30
Pahang	54	58
Perak	35	48
Selangor	55	57
Trengganu	3	6
Total	303	342

on two new films, one dealing with Pink Disease and one with Group Processing Centres. These films will be made by the Malayan Film Unit and are expected to be completed and in use on the mobile units late in 1962.

Agricultural Shows and Sheet Making Competitions

The Service participated in eighteen agricultural and other shows occupying 26 days. At the Malayan Agri-Horticultural Association Show in Kuala Lumpur and at State Agricultural Shows an exhibition stall illustrating the operation of a Group Processing Centre was used. This included an activated figure and was very successful in attracting attention.

At six shows arranged by other organisations, sheet-making competitions were arranged by the Service. Twenty-four other sheet making competitions were arranged as part of specific advisory campaigns on improved processing methods in Selangor, Malacca, Negri Sembilan, Johore and Kedah. The campaigns comprised film shows, illustrated lectures and demonstrations and the sheet-making competitions formed a climax for each.

Five hundred and forty-three smallholders took part in the thirty sheet-making competitions organised both at shows and during the advisory campaigns. Prizes in cash and kind were generously donated by several commercial firms, private individuals and Smallholders' Associations.

Illustrated Lectures and Discussion Groups

Each Rubber Instructor has been issued with a small projector, a battery and four series of coloured slides—on budgrafting, tapping, sheet making and cover plants. With the slides, lecture notes were supplied and both Rubber Instructors and Assistant Rubber Instructors used these as the basis for informal evening lectures to small groups of smallholders.

Another important group activity was the organisation by Assistant Rubber Instructors of informal discussion groups, meeting at regular intervals to discuss topical smallholding problems. These proved both popular and effective.

Both illustrated lectures and discussion group meetings were held frequently in all States, as shown in *Table 53.*

TABLE 53. ILLUSTRATED LECTURES AND DISCUSSION MEETINGS, 1961

State	Illustrated Lectures	Discussion Meetings
Johore	157	337
Kedah/Perlis	46	79
Kelantan	85	82
Malacca	46	19
Negri Sembilan	64	56
Pahang	42	23
Penang/P.Wellesley	5	—
Perak	154	88
Selangor	143	160
Trengganu	35	29
Total	777	873

Publications

In conjunction with the F.A.O. International Seed Campaign which, in Malaya, took the form of a one month campaign to publicise the value of improved planting materials, a leaflet illustrated in colour and two coloured posters were produced by the Service. Although issued as a part of the campaign, these three publications are of use in normal advisory work and will continue to be distributed.

During the latter part of 1960 and early 1961 a large number of 'contact leaflets' were distributed by field staff. These leaflets comprised two pages, the first explaining briefly the purpose of the Smallholders' Advisory Service and the assistance available to smallholders, while the second was a form which smallholders seeking advisory visits could post back to field staff. Few requests for visits were obtained in this way and the leaflets were modified. The revised format is a simple single-sheet leaflet with coloured titles. It gives brief information on the Service and invites smallholders to contact the Rubber Instructor or Assistant Rubber Instructor whose name and address is stamped at the end of the leaflet. These leaflets will be distributed in large numbers so that as many smallholders as possible may be aware of the Service which exists for their benefit.

Regular contributions of technical articles to the R.I.(R).B. newspaper *Arah Kema'muran* continued, at least one article being provided for each monthly issue.

Investigations

Three surveys to investigate specific problems were carried out by field staff and the field work of a fourth was completed by R.R.I.M. and R.I.(R).B. Scholars at the College of Agriculture as an exercise during their long vacation.

One survey covered replanted holdings in Kelantan and Trengganu for which Replanting Grant instalments had been deferred. The proportion of holdings with instalments deferred in these States is disturbingly high but the reasons for each deferment are not precisely known. The survey, results of which are being analysed, should clarify the position and indicate what special advisory effort is necessary.

The second survey, carried out on a countrywide basis, aimed at discovering the incidence of brown bast on smallholdings and any relation between the incidence and planting material or soil type. The field work was carried out very rapidly by Assistant Rubber Instructors during December and the data are now being analysed.

The survey of smallholdings in the vicinity of Kampong Gesir Tengah near Tanjong Malim was completed as a preliminary to the establishment of an experimental group processing centre. This centre was under construction at the end of the year and expected to commence operation after the Muslim fasting month early in 1962.

Scholars from the College of Agriculture made a survey of conditions on smallholdings in Negri Sembilan replanted under the Replanting Scheme during 1954: Data have since been tabulated and preliminary consideration suggests a picture very similar to that disclosed by the previous survey of replanted holdings carried out in 1957 – 58.

Separate reports on each of the surveys mentioned above will be prepared and detailed results made available elsewhere.

Preliminary work on a survey of Group Processing Centres to be carried out by students of the University of Malaya next year was completed. Field staff obtained information on the size of all centres in Selangor and this will be used in planning the survey which it is hoped will provide not only detailed information on group processing centres but also information on the holdings supplying latex to the centres. In this way some information on the yield per acre obtained by smallholders from different planting materials should be obtained.

J. M. F. Greenwood
Smallholders' Advisory Officer

Estates Advisory Service Division

During the year, the Service has continued to handle all routine advisory work to estates (holdings of 100 acres or more), covering those aspects of production formerly dealt with by Soils, Botanical and Pathological Divisions. The staff, consisting of five officers including the Head of Division, is such that verbal advice can be given in the Tamil and Chinese languages as well as in English; English continues to be the medium for advisory correspondence. The year has seen the emergence of a fairly clear pattern in the work of the Service; a pattern determined by the differing needs of the large, company-owned estates and of the small, proprietary holdings. To the former, which already obtain advice from a number of quarters, the Service's function is almost entirely consultative. Visits are made on request, or when correspondence proves inadequate, and are generally related to specific problems.

On the smaller estate, however, there is often a need for advice on a broader scale, relating to managerial policy as a whole; for instruction in modern agricultural principles; and for a wider familiarity with the function and facilities of the R.R.I.M. Ways in which these needs are being met are discussed below.

Planters' Conference

In July, the Division organised the first Planters' Conference since before the war. This was held at the Institute and was attended by 140 estate managers, visiting agents and other members of the planting community. On the morning of the first day, three papers on the subject of 'Tapping and Yield Stimulation' were presented and discussed; in the afternoon there was open discussion on 'Weed Control and Herbicides', 'Cover Plants, Manuring and Wind Damage' and 'Root Disease Control'. The proceedings were reported in *Planters' Bulletin 56*, September 1961. A second morning was devoted to a tour of the R.R.I.M. Experiment Station at Sungei Buloh.

This venture, which aimed at stimulating a free interchange of ideas and opinions between planters from all parts of the country, was considered sufficiently successful for a second Conference, on a somewhat enlarged scale, to be planned for 1962.

EDUCATIONAL AND ADVISORY

Courses

In May, a five-day Lecture Course for Estate Assistants was organised at the Institute, and the ninety-six available places were fully taken up. The lectures, designed to present current thinking and recommendations on all aspects of production and processing, were given by officers of the Research Divisions.

A second one-week course, of a more practical nature, was arranged at the Experiment Station. This was intended primarily for officials of certain Government bodies, and a number of overseas trainees.

Group Discussions

As the need for instruction, in some of the more fundamental principles of plantation practice, among the owners and managers of small estates became more strongly felt, a means was sought whereby individual estate visits could be complemented by some form of group instruction. A set of slides presenting in graphic form the principles of manuring was prepared. Our Chinese Advisory Officers, when on a tour of advisory visits, would then arrange an informal gathering of planters, often in an estate owner's house, at which these slides would be shown. It was stressed that they were to form the starting-point of a discussion rather than a formal lecture.

By the end of the year, eleven such Group Discussions had been held, in various parts of the country. They were attended by a total of 161 Chinese planters. They proved highly popular and successful, both as a means of imparting instruction and for feeding-back information on the problems faced on such estates. Sets of slides on other topics are now being prepared, and the method will also be adapted for use with Tamil-speaking planters.

Estate Visits

These form the most important part of the Service's work. During the year, 559 such visits were made, of which 131 were 'contact' visits to estates which had never requested the Institute's help, in order to acquaint the owners with the existence of the Service and to ascertain the nature of their advisory needs.

Correspondence

Much advice is still given by correspondence, and the number of letters despatched again shows an increase of almost 50% over the previous year. In addition, many planters—in particular, an increasing number of Chinese—prefer the greater directness of the telephoned enquiry.

Visitors

Two hundred and thirteen people, mostly proprietary estate owners, visited the Institute, and forty-three parties, involving one hundred and seven planters, were conducted round the Experiment Station. Visits of this kind are warmly encouraged since they go far towards establishing the right relationship between the planter and the Institute.

Notes are given below on points of interest encountered in advisory work on various topics.

Planting Operations and Maintenance

With the termination of the present Government Replanting Scheme due at the end of 1962, there has been a detectable acceleration in the rate of replanting, especially among the proprietary estates, during the year. Many are now seeking our advice in the early stages and are thus able to start on the right lines.

In their older plantings, many small estates carry too high a stand per acre, and the complex question of planting density is little understood. It is to form the subject of the second set of slides prepared for Group Discussions.

Manuring

There is a fairly steady demand for advice on this subject, either to overhaul an estate's general fertiliser policy, or in relation to localised areas of poor growth. Many enquiries arise from the wider range of branded fertilisers becoming available on the Malayan market.

Cover Plants and Weed Control

Although the ban on sodium arsenite was postponed beyond the end of the year, many estates have been experimenting with other chemicals, realising that in future the planter will need a more varied armoury of herbicides at his disposal. Much correspondence on this topic concerns the identification of plant specimens and their classification as harmful or beneficial.

There is still a tendency for money spent on the establishment of legume cover crops to be wasted through failure to give them adequate after-care.

Planting Material

There is no lack of interest in this subject, and the principles of clone selection are generally better understood. The publication of the *Planters' Bulletin* in Chinese has been particularly helpful in this respect, as in other phases of our work. It is still sometimes necessary to discourage premature large-scale planting of experimental clones.

The RRIM 700 series clones have aroused considerable interest on estates.

Tapping and Stimulation

New tapping systems and the use of yield stimulants as a routine practice have found ready acceptance on the larger estates. Many proprietary estate owners, however, are still prejudiced against stimulation, sometimes having had disappointing results from using the method on very poor old rubber. There is much scope for extension work in this field.

Diseases, Pests and Injuries

Advice on root disease control is still required, and every effort is made to stress the underlying principles of the recommended methods. There is a fairly regular flow of specimens for the diagnosis of minor maladies and the identification of pests. In this, as in all other matters, close liaison is maintained with the appropriate Research Officers.

J. H. CHAPMAN
Acting Head of Estates Advisory Service

Publications and Information

Papers on completed research work are normally published in the *Journal of the Rubber Research Institute of Malaya* although certain aspects of the Institute's research are reported in more specialised scientific journals. Advice to rubber planters is published in *Planters' Bulletin* and, from March 1961, in similar bulletins issued in Malay and Chinese. Advisory books, booklets and leaflets are issued on specialised topics from time to time.

The various publications issued by the Institute during the year are described below. A complete list of contributions to journals by Institute staff is presented immediately after this report under the heading 'Publications by R.R.I.M. Staff 1961'.

Annual Report. The Annual Report 1960 was published early in October.

Journal. Parts 1 and 2 of Volume 17 were issued during the year. The work of indexing back numbers was completed with the issue of an Author Index for Volumes 1-12, and Author and Subject Indexes for Volumes 13 and 14.

Planters' Bulletin. There has been a notable increase, mainly within Malaya, in the distribution of this advisory journal in the two-year period 1960-1, from 3,500 to 4,500. A cumulative subject index for 1952-9 was published in March, and at the same time a new system of indexing was introduced whereby indexes are cumulated at intervals of 2, 4 and 8 years. Two issues were devoted to Conferences, the January issue covering the Natural Rubber Research Conference of the previous year and the September issue covering the Planters' Conference held in July.

Planters' Bulletin (Malay and Chinese languages). The first issue was made in March and subsequent ones were in June, September and December. The majority of the articles were selected from the English version of *Planters' Bulletin* for the period 1952-7, and then brought up to date and re-written to a technical level suitable for smallholders and small estate owners before translation.

Preliminary surveys had indicated that there was a potential demand approximately as follows: Malay (Rumi) 6,000, Malay (Jawi) 10,000; Chinese 9,000 (including about 2,000 small estates and 7,000 smallholders). There was a steady increase in the mailing list throughout the year. At the end of 1961 the distribution was as follows: Malay (Rumi) 3,800; Malay (Jawi) 6,700; Chinese 9,100.

Miscellaneous. The *Proceedings of the Natural Rubber Research Conference* were published as a 1,000-page bound volume in March 1961; the contributions by R.R.I.M. authors were listed in last year's *Annual Report.* Nearly 2,000 copies of *Maladies of Hevea in Malaya,* published in 1959, had been distributed by the end of 1961. Three documents* were issued in the series *Research Archives of the R.R.I.M.*

Contributions to non-R.R.I.M. publications. Eleven scientific papers were contributed to outside journals durings the year.

* See 'Publications by R.R.I.M. Staff 1961', p. 138.

LIBRARY

The object of the reorganisation of the Library, begun in mid-1959, was to increase the efficiency of the Library by providing more shelf space, by recataloguing the whole stock and by improving and extending services to users.

The rehousing of the stock on the new shelves was completed early in 1961. The introduction of steel shelving and a mezzanine floor has provided sufficient space to allow for expansion during the next ten years.

Work continued on the reclassification and cataloguing of the books and by the end of the year about half of this task had been completed. Some improvements were made in the Library services: a more efficient journal circulation scheme was introduced, sorting and regrouping of the pamphlet collection began, and a microfilm reader was installed. There was a considerably increased demand for the photocopying service provided by the Library.

About 550 books were added to the stock and there were 35 new subscriptions to journals; 21 translations were made. At the end of the year the total holdings of books, current journals and R.R.I.M. translations were 5,000 (approximately), 435 and 712 respectively.

W. J. Baulkwill
Publications Officer

Publications by R.R.I.M. Staff 1961

(This List does not include contributions by R.R.I.M. staff to *Proceedings of the Natural Rubber Research Conference, Kuala Lumpur 1960,* published in 1961; these contributions were listed in the previous *Annual Report*)

GENERAL

BOLTON, J., BOATMAN, S. G., GALE, R. S. and MOIR, G. F. J. Natural rubber research. *Nature* 1961, **187**, p.193.

SOILS DIVISION

Scientific journals.

BOLTON, J. and SHORROCKS, V. M. The effect of magnesium limestone and other fertilisers on a mature planting of *Hevea brasiliensis*. *J. Rubb. Res. Inst. Malaya* 1961, **17**, p.31.

MIDDLETON, K. R. Elimination of phosphate interference in EDTA determinations of calcium and magnesium in plant ash. *The Analyst* 1961, **86**, No. 1019, p.111.

SHORROCKS, V. M. Leaf analysis as a guide to the nutrition of *Hevea brasiliensis* I. Sampling technique with mature trees: Principles and preliminary observations on the variations in leaf nutrient composition with position on the tree. *J. Rubb. Res. Inst. Malaya* 1961, **17**, p.1.

SHORROCKS, V. M. and WATSON, G. A. Manganese deficiency in *Hevea:* The effect of soil application of manganese sulphate on the manganese status of the tree. *J. Rubb. Res. Inst. Malaya* 1961, **17**, p.19.

Planters' Bulletin.

Correction of manganese deficiency	*Planters' Bulletin*	*53*
Mixed and compound fertilisers	,,	*57*
Loss of ammonia from surface application of urea fertiliser	,,	*57*
Cover plants, manuring and wind damage	,,	*57*
Substitutes for sodium arsenite	,,	*57*

Other journals.

WATSON, G. A. and WYATT-SMITH, J.* Eradication of the bamboo, *Gigantochloa levis* (Blanco) Merr. *The Malayan Forester* 1961, **24**, 225.

WATSON, G. A. Nature conservation and land usage. *The Malayan Nature Journal*, November, 1961.

* Silvicultural Research Officer, Forest Research Institute, Malaya.

BOTANICAL DIVISION

Scientific journals.

BUTTERY, B. R. Investigations into the relationship between stock and scion in budded trees of *Hevea brasiliensis*. *J. Rubb. Res. Inst. Malaya* 1961, **17**, p.46.

TINLEY, G. H. Effect of ferric dimethyldithiocarbamate on the rooting of cuttings of *Hevea brasiliensis*. *Nature, Lond.* 1961, **191**, No. 4794, p.1217.

Research Archives of the Rubber Research Institute of Malaya. The following documents for limited circulation were issued in this series.

BUTTERY, B. R. Analyses of variance and additional information relating to 'Investigations into the relationship between stock and scion in budded trees of *Hevea brasiliensis*'. *Res. Arch. Rubb. Res. Inst. Malaya,* Doc.15.

PAARDEKOOPER, E. C. A forecast of Malayan rubber production, 1960–70. *Res. Arch. Rubb. Res. Inst. Malaya,* Doc.13.

PAARDEKOOPER, E. C. Report on the RRIM 'Exchange Clones' trials II. *Res. Arch. Rubb. Res. Inst. Malaya,* Doc.14.

Planters' Bulletin.

Editorial: Malayan rubber production 1960–70 ... ... *Planters' Bulletin 53*
Planting materials used in Malaya 1959 ... ... ,, *53*
Planting recommendations 1961–2 ... ... ,, *53*
RRIM 600 series clones ... ... ,, *53*
Pollarding and pruning of mature stands of clone RRIM 501 ,, *55*
Depth of bark scraping before the application of yield stimulants ... ... ,, *55*
Editorial: Wind damage ... ... ,, *57*

Other journals.

WYCHERLEY, P. R. A botanist's approach to natural rubber production. *New Scientist* 1961, **9**, No. 225, p.620.

WYCHERLEY, P. R. Reflections on *Hevea* propagation. *Mag. Agric. Soc. Univ. Malaya* 1961, **1**, p.1.

Conference paper.

DE JONGE, P. Tapping of young rubber. Presented at the Planters' Conference July 1961 and printed in *Planters' Bulletin 56*, September 1961.

PATHOLOGICAL DIVISION

Scientific journals.

RAO, B. S. Pollination of *Hevea* in Malaya. *J. Rubb. Res. Inst. Malaya* 1961, **17**, p.14.

Planters' Bulletin.

Root disease control ... ... *Planters' Bulletin 54*
Fasciation: A harmless deformity of rubber ... ... ,, *54*

CHEMICAL DIVISION

Scientific journals.

SETHU, S. Reduction of viable bacteria in latex by ultra-violet irradiation. *J. Rubb. Res. Inst. Malaya* 1961, **17**, p.40.

SOUTHORN, W. A. Thread-like reticulum in latex from *Hevea brasiliensis* and its relation to latex particles, *Nature, Lond.* 1961, **189**, No. 4769, p.1000.

TAYSUM, D. H. Effect of ethylene oxide on the tapping of *Hevea brasiliensis*. *Nature,* 1961, **191**, No. 4795, p.1319.

WREN, W. G. The chemistry of natural rubber production. *Rubb. Chem. Technol.* 1961, **34,** p.378.

Planters' Bulletin.

SP rubber during 1960 ... ... *Planters' Bulletin 54*
Editorial: Chemical Advisory Service ... ... „ *54*
TCR in Indonesia ... ... „ *54*

Other journals.

SOUTHORN, W. A. Microscope studies at the R.R.I.M. on fresh *Hevea* latex. *Rubber Developments* 1961, **14**, p.2.

DRAKE, G. W. P.A. 80 adds impetus to SP rubber progress. *Rubber Developments* 1961, **14**, p.51.

Miscellaneous. Technically Classified Natural Rubber. *Technical Bulletin* No. 40 (a cyclostyled serial publication for restricted distribution) was published.

SENIOR STAFF*

ADMINISTRATION

C. C. Webster, B.Sc. (Agric.), Dipl. Agric. (Wye), A.I.C.T.A., Ph.D., *Director.* (16 January 1961)
C. G. Akhurst, B.Sc., A.R.C.S., A.I.C.T.A., *Deputy Director.* (7 October 1930) *Acting Director* (February 1960). (Retired 9 October 1961)
J. C. Reeves, F.C.C.S., *Secretary.* (11 September 1950)
H. F. Logan, *Assistant Secretary.* (12 January 1959)
Tan Beng Lin, A.A.S.A., *Accountant.* (March 1961)
J. A. Faulkner, *Maintenance Engineer.* (1 November 1955)

PUBLICATIONS AND INFORMATION SECTION

W. J. Baulkwill, B.A., N.D.A., *Publications and Information Officer.* (6 January 1959)
J. S. Soosai, B.Sc., *Librarian.* (1 September 1961)

STATISTICS DIVISION

D. R. Westgarth, M.Sc., *Head of Division.* (19 November 1959)
A. Fong Chu Chai, Dip. Arts, B.Sc. *Statistician.* (8 July 1949)
G. Chidambara Iyer, M.Sc., *Assistant Statistician.* (20 August 1955)
R. Narayanan, M.Sc., *Assistant Statistician.* (15 June 1961)

EXPERIMENT STATION

R. F. Harley, M.C., F.I.S.P., *Manager.* (27 August 1937)
J. D. Macritchie, B.Sc. (Agri.), *Assistant Manager.* (15 December 1954)
C. Y. Ross, *Assistant Manager.* (23 October 1959)
J. F. McEwen, B.Sc. (For.), *Assistant Manager.* (1 March 1960)
G. A. Gilbertson, *Resident Engineer.* (18 May 1959)

SOILS DIVISION

G. A. Watson, M.Sc., Ph.D., A.R.C.S., D.I.C., F.R.I.C., *Head of Division.* (8 November 1955)
V. M. Shorrocks, M.A., D.Phil., M.I. Biol., *Plant Physiologist.* (28 August 1957)
K. R. Middleton, M.Sc., A.R.I.C., *Soils Chemist.* (16 October 1958)
J. Bolton, B.Sc., A.R.I.C., *Soils Chemist.* (24 October 1958)
P. Riepma, I.i., *Agronomist.* (27 January 1961)
M. M. Guha, Ph.D., Assoc. I.A.R.I., *Assistant Soils Chemist.* (20 May 1955). On study course in Scotland

* The date of first appointment to the senior staff is given in brackets after each name.

K. Raman, M.Sc., Ph.D., *Assistant Soils Chemist.* (23 April 1957). (Resigned 11 July 1961)
K. Ratnasingam, *Assistant Soils Chemist.* (1 January 1960)
Wong Phui Weng, B.Sc., *Assistant Soils Chemist.* (1 August 1960)

BOTANICAL DIVISION

C. W. Brookson, B.Sc., *Head of Division.* (23 August 1949)
P. de Jonge, l.i., *Botanist.* (29 December 1950)
P. R. Wycherley, Ph.D., *Botanist.* (26 January 1953)
J. M. Ross, B.Sc., *Botanist.* (5 December 1955)
S. G. Boatman, Ph.D., *Botanist.* (2 November 1956)
J. K. Templeton, M.Agr. Sc., D.Phil., *Botanist.* (24 January 1958)
E. C. Paardekooper, l.i., *Botanist.* (23 June 1958)
G. H. Tinley, M.Sc., *Botanist.* (26 November 1958)
B. R. Buttery, Ph.D., *Botanist.* (18 August 1959)
C. F. Arlett, Ph.D., *Botanist.* (2 September 1960)
Ng Eng Kok, B.Sc., M.Sc., Ph.D., *Botanist.* (21 March 1961)
M. M. Chandapilla, B.Sc., *Assistant Botanist.* (2 January 1958)
P. D. Abraham, B.Sc. (Agric.), *Assistant Botanist.* (13 October 1958)
J. B. Gomez, B.Sc., *Assistant Botanist.* (12 September 1960)
S. K. Majumder, B.Sc., *Assistant Botanist.* (3 October 1960)
Low Choong San, B.Sc., *Assistant Botanist.* (2 October 1961)
S. Subramaniam, B.Sc., *Assistant Botanist.* (1 December 1961)

PATHOLOGICAL DIVISION

A. Newsam, Ph.D., *Head of Division.* (5 April 1947)
R. N. Hilton, M.A., *Pathologist.* (7 September 1948)
R. A. Fox, B.Sc., B.Agr., *Microbiologist.* (2 March 1954)
R. L. Wastie, B.A., Ph.D., *Pathologist.* (8 October 1961)
K. P. John, B.A., *Assistant Pathologist.* (16 November 1936)
B. S. Rao, M.A., D.P.P., *Assistant Entomologist.* (6 June 1952)

CHEMICAL DIVISION

W. G. Wren, B.Sc., A.R.C.S., D.I.C., F.I.R.I., *Head of Division* (7 January 1950)
G. W. Drake, B.Sc., M.A., *Chemist.* (8 March 1948)
W. A. Southorn, Ph.D., A.R.I.C., *Chemist.* (18 November 1952)
J. E. Morris, B.Sc., A.R.I.C., *Advisory Officer.* (20 June 1952)
R. S. Gale, B.Sc., A.C.G.I., A.M.I. Chem.E., *Chemical Engineer.* (2 May 1951) (Resigned 31 August 1961)
D. J. Graham, A.S.T.C., A.R.A.C.I., *Advisory Officer.* (31 March 1953)
D. H. Taysum, M.Sc., D.I.C., *Microbiologist.* (13 September 1954)
G. F. J. Moir, B.Sc., *Biochemist.* (2 February 1955). (Resigned 18 September 1961)
B. C. Sekhar, B.Sc., M.S., A.R.I.C., A.I.R.I., *Polymer Chemist.* (15 September 1949)
C. A. K. Salgado, B.Sc., A.Inst.P., *Technologist.* (22 April 1957)

F. W. Shipley, Ph.D., A.R.I.C., *Chemist*. (6 August 1958). Seconded from N.R.P.R.A.
P. S. Nielsen, A.N.C.R.T., *Technologist*. (1 October 1958)
S. N. Angove, A.N.C.R.T., A.I.R.I., A.P.I., *Technologist*. (26 August 1959)
R. C. H. Hsia, B.Sc., Ph.D., D.I.C., A.R.I.C., *Analyst*. (2 January 1953)
J. J. McDonnell, B.Sc., M.Sc., *Biochemist*. (11 January 1960)
S. Sethu, B.E. (Chem.), M.Sc. (Eng.), D.I.C., A.M.I.I.Ch.E., *Chemical Engineer*. (1 September 1955)
R. N. Muthurajah, B.Sc., B.Sc.(Chem.Eng.), D.C.T., A.M.Inst.F., *Chemical Engineer*. (1 January 1961)
B. G. Hughes, A.I.R.I., A.N.C.R.T., *Technologist*. (26 October 1961)
S. J. Tata, B.Sc., *Assistant Biochemist*. (14 December 1953)
A. Karunakaran, B.Sc., *Assistant Biochemist*. (25 November 1957). On study course in U.S.A.
N. M. Pillai, B.A., F.I.C.S., *Assistant Chemist*. (29 October 1958)
Mrs R. Pepper, B.Sc., M.Sc., *Microbiologist*. (Temporary appointment 2 January 1959)
Yeo Oon Keong, M.Sc., A.R.I.C., *Analyst*. (5 October 1959)
C. K. John, B.Sc., *Assistant Microbiologist*. (I January 1960)
Chin Peng Sung., B.Sc., *Assistant Chemist*. (8 March 1961)
G. Arumugam, B.Sc., M.S., *Factory Technologist*. (1 November 1961)

SMALLHOLDERS' ADVISORY SERVICE DIVISION

J. M. F. Greenwood, B.Sc. (Agric.), *Smallholders' Advisory Officer*. (25 November 1948)
J. G. Samuel, B.Sc. (Agric.), *Assistant Smallholders' Advisory Officer*. (27 December 1956)
Mohd. Johar bin Mohd. Rashid, *Assistant Smallholders' Advisory Officer*. (1 August, 1958)
Wong Mun Yun, *Assistant Smallholders' Advisory Officer*. (1 January 1959)
Yeoh Chong Hoe, B.Sc. (Agric.), *Assistant Smallholders' Advisory Officer*. (1 November 1960)
Chai Hon Chee, *Assistant Smallholders' Advisory Officer*. (21 June 1961)
James P. C. Wong, B.Sc., Dr.Sc.Nat., *Assistant Smallholders' Advisory Officer*. (1 July 1961)

ESTATES ADVISORY SERVICE DIVISION

F. W. Hutchison, N.D.A., C.D.A., *Head of Service*. (5 March 1948)
J. H. Chapman, B.Sc., (Agric.), *Advisory Officer*. (19 August 1955)
Lim Poh Loh, *Assistant Advisory Officer*. (6 April 1959)
N. S. Bharathi, B.Sc. (Agric.), *Assistant Advisory Officer*. (4 July 1960)
Lim Bock Tong, B.Sc. (Agric.), *Assistant Advisory Officer*. (17 October 1960)

ACCOUNTS, 1961

LIABILITIES			31.12.61	As at 31.12.6
		$ c.	$ c.	$
SUNDRY CREDITORS				
Staff		75,819.36		
Merchants		499,506.41		
Miscellaneous		23,898.44	599,224.21	657,60
STAFF CONTINGENCY RESERVE FUND				
As at 31 December 1960			330,000.00	330,00
EXCESS OF ASSETS OVER LIABILITIES				
As at 31 December 1960		5,680,887.63		
Add Excess of Income over Expenditure for the year:				
Head Office	782,324.44			
Experiment Station	36,062.92	818,387.36		
		6,499,274.99		
Less Written off:				
Leasehold Land	9,396.11			
Furniture	47,257.96			
Building	769,699.74	826,353.81		
		5,672,921.18		
Add cancellation of Excess Provision for Unfilled Orders		47,567.65	5,720,488.83	5,680,88
		Carried forward	6,649,713.04	6,668,49

ASSETS

AND AND BUILDINGS	$ c.	$ c.	As at 31.12.60 $
2¼ Mile Compound			
Land as at 31 December 1960	15,784.35		
198 and 200 Ampang Road:			
At nominal value	2.00	15,786.35	15,786
3rd Mile Compound			
Land as at 31 December 1960	31,440.35		
251, 253, 255, 257, 259 and 261 Ampang Road:			
At nominal value	6.00	31,446.35	31,446
3¼ Mile Compound			
Land as at 31 December 1960	27,582.50		
262, 264, 266, 268 and 270 Ampang Road:			
At nominal value	5.00	27,587.50	27,588
4th Mile Compound			
Land as at 31 December 1960	2,000.00		
74, 4th Mile Ampang Road:			
At nominal value	1.00	2,001.00	2,001
Eaton Road Compound			
Land as at 31 December 1960	17,147.08		
1, 3, 5 and 7 Eaton Road:			
At nominal value	4.00	17,151.08	17,151
Wickham Road and Ridley Close			
Land as at 31 December 1960	43,623.50		
9 Bungalows — At nominal value	9.00	43,632.50	43,633
Ukay Heights			
As at 31 December 1960	372,612.78		
Less transfer to Furniture Account	40,558.35		
	332,054.43		
Less Written off:	332,047.43	7.00	372,613
Ulu Klang			
Land as at 31 December 1960	7,705.00		
Workmen's Quarters — At nominal value	1.00	7,706.00	7,706
Ampang Road Laboratories			
As at 31 December 1960			
Land	19,526.00		
Buildings	486,412.49		
	505,938.49		
Less Written off	336,462.44		
	169,476.05		
Additions during the year	44,374.95	213,851.00	505,938
Sungei Buloh Laboratories and Houses			
Laboratories as at 31 December 1960	104,073.36		
Additions during the year	41,320.42		
	145,393.78		
Less Written off	8,930.00		
	136,463.78		
Houses as at 31 December 1960 — At nominal value	24.00	136,487.78	104,097
Land and Quarters for Rubber Instructors			
As at 31 December 1960			
Land	10,827.50		
Quarters	148,378.39		
	159,205.89		
Additions during the year	87,002.80		
	246,208.69		
Less Written off:			
Building 92,314.87			
Land 9,396.11	101,710.98	144,497.71	169,552
Carried forward		640,154.27	1,297,511

	31.12.61	As a 31.12.
	$ c.	$
Brought forward	6,649,713.04	6,668,4
Carried forward	6,649,713.04	6,668,4

			31.12.61	As at 31 12.60
			$ c.	$
	Brought forward		640,154.27	1,297,511
Pilot Instruction Centre				
As at 31 December 1960				
Land	8,297.94			
Buildings	10.65			
	8,308.59			
Additions during the year	106,681.10		114,989.69	8,309
ANT AND MACHINERY				
As at 31 December 1960	12,434.08			
Additions during the year	59,009.64		71,443.72	12,434
RNITURE				
Residential Houses and Flats, Kuala Lumpur				
At nominal value		29.00		1
Quarters for Rubber Instructors				
At nominal value	20.00			
Additions during the year	3,639.03	3,659.03		10
Sungei Buloh				
At nominal value		25.00		1
Offices, Kuala Lumpur				
As at 31 December 1960		1.00		1
Library				
At nominal value		1.00		1
Laboratories				
At nominal value:				
Kuala Lumpur	1.00			
Sungei Buloh	1.00	2.00	3,717.03	2
PARATUS AND GLASSWARE				
At nominal value			1.00	1
TOR VEHICLES				
At nominal value			1.00	1
RKSHOP				
At nominal value			1.00	1
RARY BOOKS AND PERIODICALS				
At nominal value			1.00	1
				1,318,274
PERIMENT STATION DEVELOPMENT				
As at 31 December 1960	3,820,347.38			
Additions during the year	314,336.26		4,134,683.64	3,820,347
			4,964,992.35	5,138,621
NIDAD TESTING STATION				
Progress Payments			60,060.00	60,060
Sub-Station				
Survey			72.00	—
	Carried forward		5,025,124.35	5,198,681

	31.12.61	As at 31.12.60
	$ c.	$
Brought forward	6,649,713.04	6,668,491

REPORT OF THE AUDITORS TO THE BOARD OF THE RUBBER RESEARCH INSTITUTE OF MALAYA

We have examined the above Balance Sheet with the books and vouchers of the Institute and have obtained all the information and explanations we have required.

Titles to certain of the Institute's lands have not yet been issued.

Subject to the foregoing, in our opinion, the said Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institute's affairs at 31 December 1961 according to the best of our information and the explanations given to us and as shown by the books of the Institute.

Kuala Lumpur,
March, 1962

Sgd Peat, Marwick, Mitchell & Co.
Chartered Accountants
Certified Public Accountants (Malaya)
Auditors

	6,649,713.04	6,668,49

			31.12.61	As at 31.12.60
			$ c.	$
	Brought forward		5,025,124.35	5,198,681
CKS				
Petrol, Oil and Chemicals				
Head Office		148.04		356
Experiment Station		12,520.76	12,668.80	15,753
Empty Containers and Drums				
Head Office		306.50		218
Experiment Station		2,155.40	2,461.90	1,529
Stationery				
Head Office			5,306.30	4,609
Sundry Materials				
Head Office		28,434.85		17,894
Experiment Station		9,201.56	37,636.41	12,200
Rubber				
Experiment Station (At Market Price)			30,242.24	88,315.65	26,648
				79,207
				5,277,888
			415.00	400
NDRY DEPOSITS				
NDRY DEBTORS				
Staff				
Loans for Motor Vehicle Purchase			410,243.42		365,006
Travelling and Sundries			47,432.40		71,049
			457,675.82	
General				
Head Office		182,687.98		132,166
Experiment Station		850.55	183,538.53	925
Interest Accrued on Investments			3,674.65	3,675
Payments in Advance				
Head Office		3,896.00		12,714
Experiment Station		3,513.00	7,409.00	652,298.00	4,094
				589,629
CAL AND BRITISH GOVERNMENT SECURITIES				
(Held for account of Staff Contingency Reserve Fund)				
$ 15,000/- 4½% Singapore Municipal Debenture Stock 1930-70/80 ($17,537/-†) ($11,474/-*)			15,000.00		15,000
$160,000/- 3% Malayan Union Government Loan 1946-62/66 ($160,000/-†) (136,996/-*)			160,000.00		160,000
£ 20,600/- 3½% British War Loan 1952 ($145,322/-†) ($104,551/-*)			145,322.05		145,322
$ 40,000/- Federation of Malaya 5½% Registered Stock 1979/82 ($40,000/-†) ($35,465/-*)			40,000.00	360,322.05	40,000
† Total Original Cost — $362,859/-					
* Total Market Value as at 31 December 1961 — $282,566/-					
SH AT BANK AND IN HAND				
At Bank — Current Account			514,509.24	
In Hand			8,728.75	523,237.99	440,252
				6,649,713.04	6,668,491

Income & Expenditure Account (Excluding Experiment

EXPENDITURE			31.12.61	Year to 31.12.60
			$ c.	$
To	International Rubber Research Board and International Rubber Development Committee		—	2,143
	Natural Rubber Bureau		4,719.25	32,049
	Board Meetings		4,588.52	6,106
	Salaries of Staff on Agreement:			
	Research — Division A	$1,158,888.14		1,156,859
	Research — Division B	245,440.88	1,404,329.02	204,897
	Salaries of Staff not on Agreement		1,520,377.93	1,355,291
	Provident Fund		261,937.39	241,737
	Medical		59,874.80	52,849
	Travelling		171,733.18	171,569
	Office General Charges		72,522.30	64,097
	Rents, Rates and Taxes		32,931.53	30,631
	Insurance		27,273.31	29,698
	Rentals		9,100.00	4,704
	Laboratory General Charges		22,960.68	14,807
	Buildings and Grounds		174,845.75	207,002
	Furniture and Office Equipment		126,909.77	73,895
	Fixtures and Fittings		63,171.59	77,795
	Plant and Machinery		116,009.33	102,433
	Vehicles Maintenance		7,160.86	16,421
	Workshop		11,625.77	12,670
	Apparatus and Glassware		294,828.31	326,594
	Laboratory Chemicals		67,363.71	51,815
	Publications		92,032.28	32,377
	Deposit on Publication of N.R.R.C. Proceedings written off		14,614.13	—
	Library (Books and Periodicals)		38,358.26	35,516
	Exhibitions and Conferences		7,374.41	70,906
	Smallholders' Advisory Service		1,209,182.81	1,012,728
	Estates Advisory Service		122,736.31	122,987
	Field and Factory Experiments		129,793.41	100,527
	Technical Classification		42,500.45	31,888
	Gratuities to Staff		36,065.17	72,921
	Passages		163,673.12	153,875
	Grant towards Passages		174.81	866
	Scholarship		5,000.00	10,021
	Investigations outside Malaya		26,651.86	—
			6,342,420.02	5,880,674
	Excess of Income over Expenditure for the year		782,324.44	670,629
			7,124,744.46	6,551,303

Income & Expenditure Account for Experiment

EXPENDITURE		$ c.	$
To	Revenue Expenditure	1,035,913.21	1 ,044,085
	Excess of Income Over Expenditure for the year	36,062.92	168,569
		1,071,976.13	1,212,654

tion) for the year ended 31 December 1961

	INCOME	31.12.61	Year to 31.12.60
		$ c.	$
y	Contributions receivable from the Malayan Rubber Fund	7,014,585.00	6,462,874
	Publications Sold	27,573.56	33,823
	Rents on Houses	15,795.47	5,091
	Interest on Loans	3,444.18	3,943
	Interest on Investments	13,848.00	13,644
	Sundry Fees Received	45,133.45	26,660
	Miscellaneous	4,364.80	5,268
		7,124,744.46	6,551,303

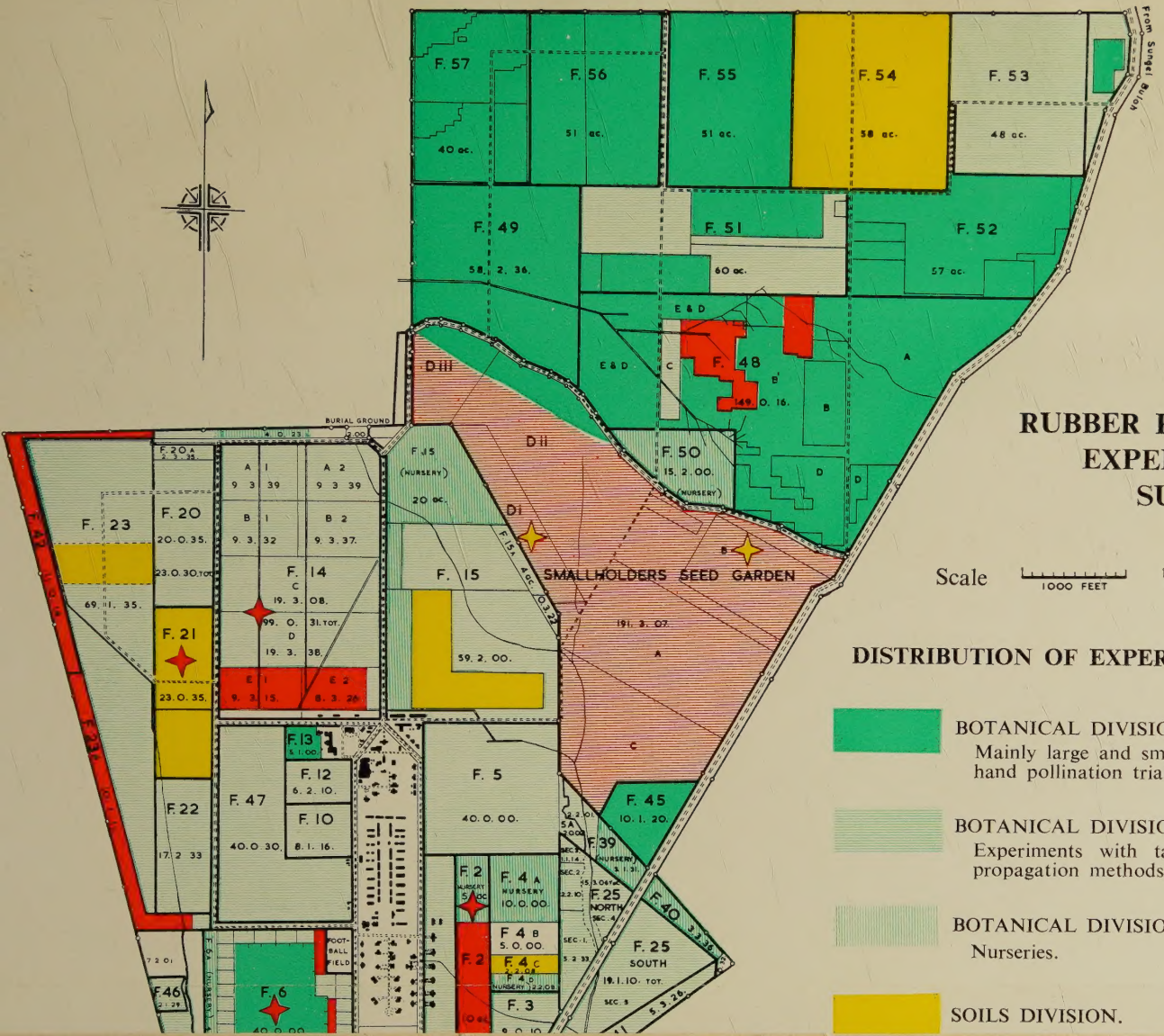
tion for the year ended 31 December 1961

	INCOME			$ c.	$
By	Sales and Stock of Rubber			919,006.03	1,129,297
	Sales of Planting Materials			35,073.93	31,409
	Miscellaneous			360.00	255
	Rubber Industry Replanting Board :				
	Refund on account of Replanting Cesses		61,413.08		51,693
	Refund on account of Anti-Inflationary Cesses		50,761.09		
	Government Replanting Grant		5,362.00	117,536.17	
				1,071,976.13	1,212,654

RAINFALL DATA FOR THE R.R.I.M. EXPERIMENT STATION, 1961

Total rainfall for the year was 92.44 in. Rain fell on 182 days.

Month	Rainfall, in.	No. of days on which rain fell	Average for 1952–1961, in.
January	4.53	11	6.12
February	6.15	15	8.36
March	13.27	22	9.97
April	10.91	21	11.40
May	4.04	10	6.70
June	5.19	12	7.60
July	4.32	13	5.58
August	3.67	10	4.93
September	5.23	14	7.58
October	6.87	12	11.17
November	14.51	20	9.76
December	13.75	22	9.71
Total	92.44	182	98.88



RUBBER RESEARCH INSTITUTE
EXPERIMENT STATION
SUNGEI BULOH

Scale 1000 FEET 10 CHAINS Total area 2979 acres

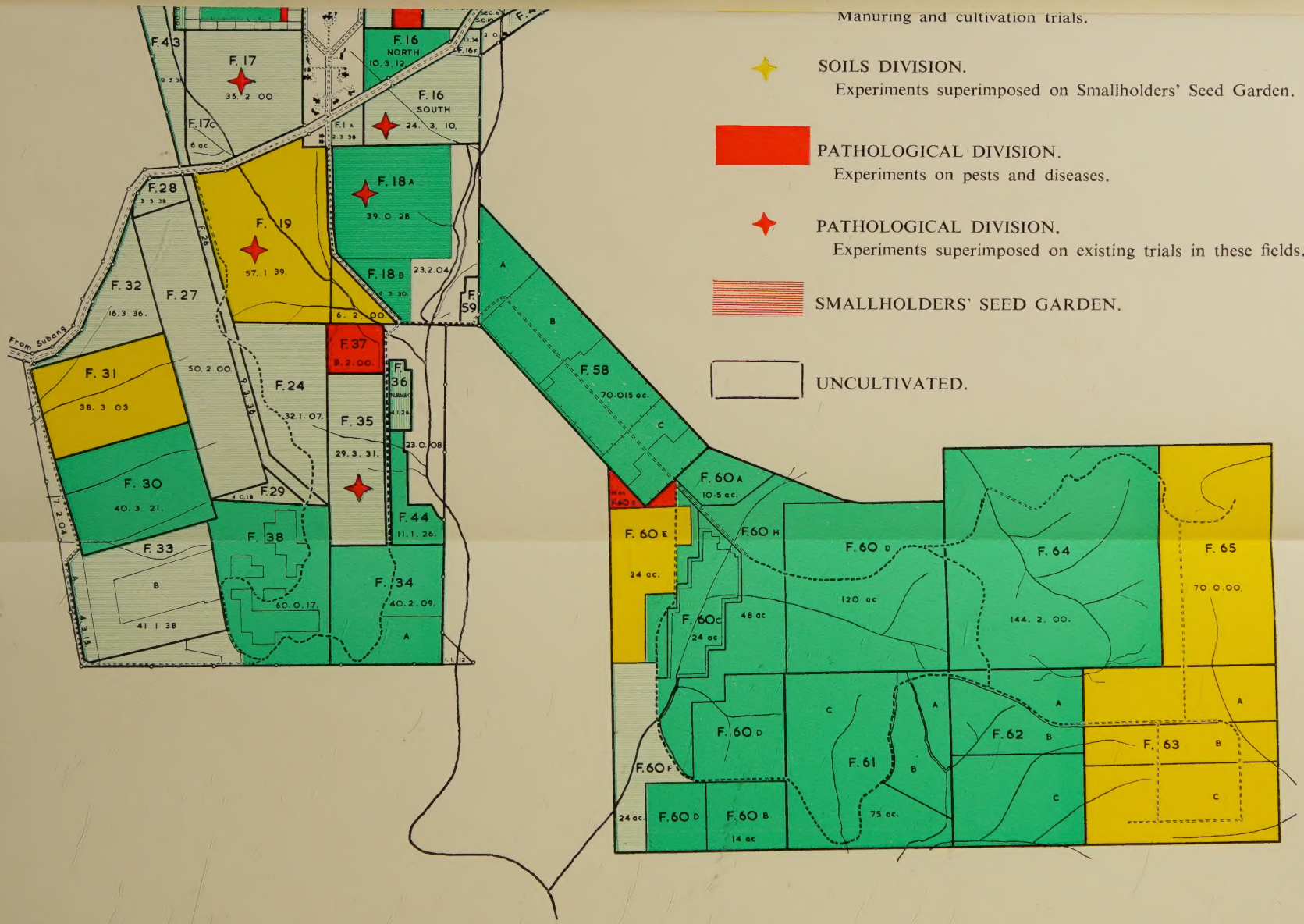
DISTRIBUTION OF EXPERIMENTS BY DIVISIONS, 1961

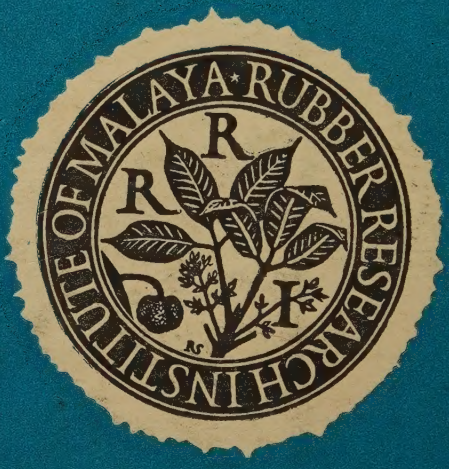
BOTANICAL DIVISION.
Mainly large and small-scale clone trials, seedling trials and hand pollination trials.

BOTANICAL DIVISION.
Experiments with tapping methods, density of planting, propagation methods, cover crops and other trials.

BOTANICAL DIVISION.
Nurseries.

SOILS DIVISION.


Manuring and cultivation trials.
SOILS DIVISION.
Experiments superimposed on Smallholders' Seed Garden.
PATHOLOGICAL DIVISION.
Experiments on pests and diseases.
PATHOLOGICAL DIVISION.
Experiments superimposed on existing trials in these fields.
SMALLHOLDERS' SEED GARDEN.
UNCULTIVATED.
From Subang
F. 43
F. 17
35. 2. 00
F. 16 NORTH
10. 3. 12.
F. 16 SOUTH
24. 3. 10.
F. 17c
6 ac.
F. 28
F. 19
57. 1. 39
F. 18 A
39. 0. 28
F. 18 B
23.2.04
F. 59
F. 32
16. 3. 36.
F. 27
6. 2. 00.
F. 37
8. 2. 00.
F. 58
70.015 ac.
F. 31
38. 3. 03
50. 2. 00
F. 24
32. 1. 07.
F. 36
NURSERY
F. 35
29. 3. 31.
23. 0. 08.
F. 30
40. 3. 21.
F. 29
F. 44
11. 1. 26.
F. 33
41 1 38
F. 38
60. 0. 17.
F. 34
40. 2. 09.
F. 60 A
10.5 ac.
F. 60 E
24 ac.
F. 60 H
F. 60 D
120 ac
F. 64
144. 2. 00.
F. 65
70 0.00.
F. 60 C
48 ac
24 ac
F. 60 D
F. 61
75 ac.
F. 62
F. 63
F. 60 F
24 ac.
F. 60 D
F. 60 B
14 ac


RUBBER RESEARCH INSTITUTE OF MALAYA
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